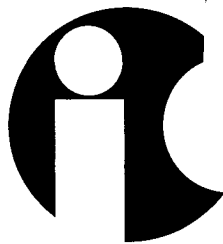




No. 14-184850-00000-0000

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Tra. 11 PATENTEIYI
Act. 411 PRESENTACION

Dep. 2020 DIR.NUEVASCR
Eve: 378 FASENACIONALI
Folios: 86



Industria y Comercio

SUPERINTENDENCIA

DELEGATURA DE PROPIEDAD INDUSTRIAL

División de Nuevas Creaciones

**SOLICITUD
PATENTE DE INVENCION**

21. EXPEDIENTE No. _____

54. TÍTULO Metodo y equipo para la
producción de chocolate, referencia
cruzada a aplicaciones relacionadas

51. CLASIFICACIÓN INTERNACIONAL _____

71. SOLICITANTE Temple University of the ---

DOMICILIO Estados Unidos de América

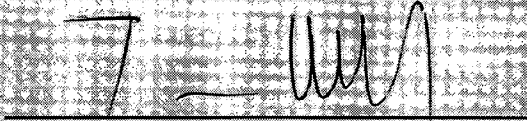
74. APODERADO Juan Carlos Uribe Restrepo

22. BOGOTÁ, D.C., Agosto 22 / 2014

	SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO  No. 14-184850- -00000-0000 Fecha: 2014-08-22 16:35:29 Dep. 2020 DIR.NUEVASCR Tra. 11 PATENTEIYII Eve: 378 FASENACIONALI Act. 411 PRESENTACION Folios: 86 cación
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DIRECCIÓN DE NUEVAS CREACIONES
SOLICITUD FASE NACIONAL -PCT

1	TIPO DE SOLICITUD	☒ Patente de invención ☒ Capítulo I	☐ Patente de Modelo de Utilidad ☐ Capítulo II
2	DATOS SOLICITUD INTERNACIONAL PCT (86)		
Solicitud Internacional No.		PCT/ US2013/023988	Fecha 31/01/2013
Publicación Internacional No.		WO 2013/116428 A9	Fecha 08/08/2013
3	TÍTULO DE LA INVENCIÓN (200 caracteres o espacios máximos)		
MÉTODO Y EQUIPO PARA LA PRODUCCIÓN DE CHOCOLATE, REFERENCIA CRUZADA A APLICACIONES RELACIONADAS			
4	CLASIFICACIÓN INTERNACIONAL (CIP)		
A23G 1/04 (2006.01) A23G 1/50 (2006.01)			
5	SOLICITANTE (S) ☐ Esta persona también es inventor. Para datos adicionales utilizar hoja de información complementaria		
APELLIDOS O RAZÓN SOCIAL		NOMBRE	IDENTIFICACIÓN
TEMPLE UNIVERSITY OF THE COMMONWEALTH SYSTEM OF HIGHER EDUCATION			
6	DATOS DEL SOLICITANTE		
DIRECCIÓN		No. TELÉFONO	
BROAD STREET AND MONTGOMERY AVENUE, PHILADELPHIA, PENNSYLVANIA 19122			
CIUDAD PHILADELPHIA		CORREO ELECTRÓNICO	
DEPARTAMENTO/ESTADO PENNSYLVANIA		NACIONALIDAD O LUGAR DE CONSTITUCIÓN	
PAÍS DE RESIDENCIA ESTADOS UNIDOS DE AMÉRICA		ESTADOS UNIDOS DE AMÉRICA	
7	INVENTOR (ES) Para datos adicionales utilizar hoja de información complementaria		
APELLIDOS		NOMBRES	NACIONALIDAD
1 TAO		RONGJIA	ESTADOUNIDENSE
2 TANG		HONG	ESTADOUNIDENSE
3			
4			
5			
DIRECCIÓN DE CORREO ELECTRÓNICO:			
8	DATOS INVENTOR (ES)		
PAÍS RESIDENCIA	DEPARTAMENTO/ESTADO	CIUDAD	DIRECCIÓN
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2. ESTADOS UNIDOS DE AMÉRICA	PENNSYLVANIA	PHILADELPHIA	4413 PINE STREET APT #4, PHILADELPHIA, PENNSYLVANIA 19104 ESTADOS UNIDOS DE AMÉRICA
3			
4			
5			
OTRO(S) SOLICITANTE(S) Y/O (OTRO(S)) INVENTOR(ES)			
☐ Los demás solicitantes y/o (demás) inventores se indican en una hoja a continuación.			
9	☐ REPRESENTANTE LEGAL ☒ APODERADO		
APELLIDOS		NOMBRES	IDENTIFICACIÓN
URIBE RESTREPO		JUAN CARLOS	C.C. 79.159.313 T.P. 54.493
DIRECCIÓN CALLE 93B No. 12-48, Piso 4o. BOGOTÁ, D.C., COLOMBIA		No. TELÉFONO 6019660	
CIUDAD BOGOTÁ. D.C. COLOMBIA		CORREO ELECTRÓNICO tum@tumnet.com	
PAÍS COLOMBIA		No. RADICACIÓN DE PROTOCOLO DE PODER GENERAL	

10	DECLARACIONES DE PRIORIDAD ☒ SI ☐ NO			
(33) PAÍS DE ORIGEN		CÓDIGO PAÍS	(31) NÚMERO	(32) FECHA (AAAA/MM/DD)
1. ESTADOS UNIDOS DE AMÉRICA		USA	61/592,648	31/01/2012
2.				
3.				
11	DECLARACIÓN SOBRE USO DE RECURSOS GENÉTICOS O BIOLÓGICOS			
Declaro que el objeto de la presente solicitud de patente fue obtenido a partir de recursos genéticos o biológicos de los que cualquiera de los países miembros de la Comunidad Andina es país de origen.				
☐ SI ☒ NO				
Nota: En caso afirmativo deberá anexar copia del contrato de acceso de recursos genéticos o productos derivados, o certificado o número de registro, expedido por la Autoridad competente.				
12	DECLARACIÓN SOBRE USO DE CONOCIMIENTOS TRADICIONALES			
Declaro que el objeto de la presente solicitud de patente fue obtenido a partir de conocimientos tradicionales de comunidades indígenas, afroamericanas o locales de países miembros de la Comunidad Andina.				
☐ SI ☒ NO				
Nota: En caso afirmativo deberá anexar la licencia o autorización de uso de conocimiento tradicional, o certificado, o número de registro expedido por la Autoridad competente.				
13	REDUCCIÓN DE TASAS			
Declaro que carezco de medios económicos para presentar la solicitud de patente.				
☐ SI ☒ NO				
Nota: En caso de ser persona natural y carecer de medios económicos, y por lo tanto, aplique la reducción de tasas a que se refiere la resolución vigente en tarifas, debe firmar la presente solicitud bajo la gravedad de juramento.				
Micro, pequeñas y medianas empresas ☐				
Universidades públicas o privadas ☐				
Entidades sin ánimo de lucro ☐				
Debe aportar los documentos que se indican en el numeral 17 de anexos				
14	AUTORIZACIÓN DE NOTIFICACIÓN EN LÍNEA ☐ SI ☒ NO			
Manifiesto que he leído y entendido perfectamente los términos y condiciones de uso de medios electrónicos para las notificaciones en línea a través de Internet de los actos administrativos proferidos por la Superintendencia de Industria y Comercio que deben ser notificados personalmente y, en consecuencia, autorizo el servicio de notificación a través de internet.				
15	COMPROBANTE DE PAGO O PAGO ELECTRÓNICO	N°	Fecha	
16	FIRMA DEL SOLICITANTE, DEL APODERADO O DEL REPRESENTANTE LEGAL			
Junto a cada firma, indicar el nombre del firmante y su calidad (si tal calidad no es obvia al leer el petitorio)				
				
17	ANEXOS			
Documentación Técnica		Documentación Jurídica		
Solicitud Internacional en castellano				
1. ☒ Descripción N° de folios:		9. ☐ Poderes, si fuera el caso.		
2. ☒ Reivindicaciones N° Reivindicaciones: 25		10. ☒ Documento que legalmente pruebe la cesión del inventor al solicitante o a su causante.		
3. ☒ Dibujos y/o figuras N° folios:		11. ☐ Copia del contrato de acceso de recursos genéticos o productos derivados, certificado o número de registro, si fuera el caso.		
4. ☒ Resumen.		12. ☐ Copia de la licencia o autorización de Conocimientos Tradicionales, certificado o número de registro, si fuera el caso.		
5. ☐ Certificado de depósito de material biológico si fuera el caso.		13. Reducción de tasas		
6. ☐ Listado de secuencias de nucleótidos y/o aminoácidos en forma digital si fuera el caso.		Micro, pequeñas o medianas empresas		
7. ☒ Arte final 12 x 12.		☐ Copia simple de la declaración de renta del año inmediatamente anterior, o en su defecto prueba documental idónea.		
8. ☐ Anexo formato digital.		☐ Documento de constancia de cumplimiento con lo establecido en la ley 905 de 2004.		
		Universidades públicas o privadas		
		☐ Copia acto de reconocimiento institucional emitido por el Ministerio de Educación		
		Entidades sin ánimo de lucro		
		☐ Copia de registro vigente en Cámara de comercio.		
		☐ Hoja de información complementaria.		
		☐ Otros, especificar		
		14. ☒ Comprobante de pago de la tasa de presentación de la solicitud.		
		15. ☐ Comprobante de pago por reivindicación de prioridad.		

	16. ☐ Comprobante de pago de la tasa por concepto de excedente de palabras en la publicación. 17. ☒ Comprobante de pago por reivindicación adicional a 10.
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CORRECTED VERSION

(19) World Intellectual Property
Organization
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(43) International Publication Date
8 August 2013 (08.08.2013)



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WO 2013/116428 A9

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31 January 2013 (31.01.2013)

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(71) Applicant: TEMPLE UNIVERSITY OF THE COMMONWEALTH SYSTEM OF HIGHER EDUCATION [US/US]; Broad Street and Montgomery Avenue, Philadelphia, PA 19122 (US).

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,

HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

- with international search report (Art. 21(3))

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[Continued on next page]

(54) Title: CHOCOLATE PRODUCTION METHOD AND APPARATUS

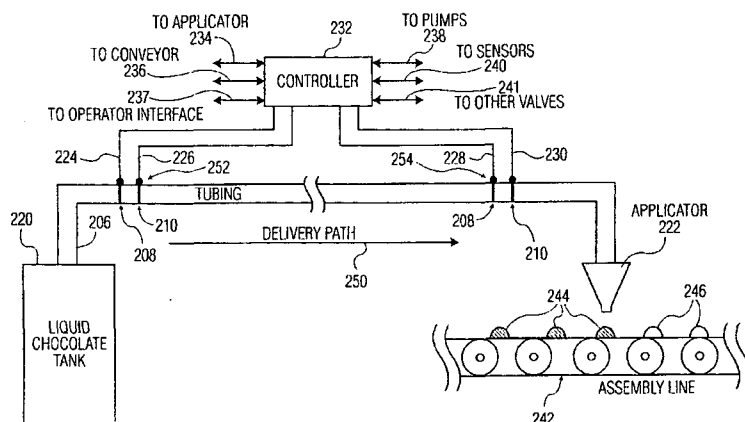


FIG. 2D

(57) Abstract: The present invention relates to a method and an apparatus for producing a chocolate product. The method includes delivering liquid chocolate having a viscosity through a pipe along a delivery path to a production station for producing the chocolate product. The liquid chocolate includes solid particles suspended within the liquid chocolate. The method changes the viscosity of the liquid chocolate by applying an electric field to the liquid chocolate in a direction along the delivery path of a strength and duration determined to aggregate the suspended solid particles into streamlined shapes extending along the direction of the delivery path.

WO 2013/116428 A9



(15) Information about Correction:
see Notice of 7 August 2014

5

CHOCOLATE PRODUCTION METHOD AND APPARATUS
CROSS REFERENCE TO RELATED APPLICATIONS

[1] This application claims priority to U.S. Provisional Application No.61/592,648,
filed January 31, 2012. The contents of U.S. Provisional Application No.61/592,648 are
5 incorporated by reference herein.

FIELD

[2] The present invention relates to chocolate production methods and apparatus.

SUMMARY

[3] The present invention relates to a method and an apparatus for producing a
10 chocolate product. The method includes delivering liquid chocolate having a viscosity
through a pipe along a delivery path to a production station for producing the chocolate
product. The liquid chocolate includes solid particles suspended within the liquid
chocolate. The method changes the viscosity of the liquid chocolate by applying an
electric field to the liquid chocolate in a direction along the delivery path to aggregate
15 the suspended solid particles into streamline shapes arranged in short chains extending
along the direction of the delivery path.

BACKGROUND

[4] Chocolate contains antioxidants and therefore may provide health benefits.
Conventional chocolate products contain excess fat which may lead to health concerns
20 such as obesity. In fact, most chocolate products contain 25% to 35% fat content.

[5] In general, liquid chocolate used to manufacture chocolate products includes
excess melted fat (e.g. cocoa butter) that is purposely added to the liquid chocolate in
an attempt to lower the viscosity for manufacturing purposes. This excess melted fat is
used because even at the chocolate melting temperature, the viscosity of liquid
25 chocolate may be too high for manufacturing. Thus, an unhealthy amount of fat may
be added to the liquid chocolate for the purposes of reducing the viscosity during
manufacturing.

BRIEF DESCRIPTION OF THE FIGURES

[6] Figure 1 is a graph depicting the relationship between shear stress and shear
30 rate for liquid chocolate according to an embodiment of the present invention.

[7] Figure 2A is a side view of an electric field being applied to the liquid chocolate
as it flows through a pipe according to an embodiment of the present invention.

[8] Figure 2B is a side view of an electric field being applied to the liquid chocolate
as it flows through a pipe according to another embodiment of the present invention.

35 [9] Figure 2C is a side view of solid columns formed perpendicular to the flow of the
liquid chocolate within the pipe according to an embodiment of the present invention.

[10] Figure 2D is a side view of chocolate product manufacturing equipment applying an electric field to the liquid chocolate according to an embodiment of the present invention.

[11] Figure 3A is a system diagram of a test bench utilized to measure the flow rate of the liquid chocolate as an electric field is applied according to an embodiment of the present invention.

[12] Figure 3B is a system diagram of another test bench utilized to measure the flow rate of the liquid chocolate as an electric field is applied according to an embodiment of the present invention.

[13] Figure 4A is a graph depicting the flow rate versus time as an electric field is applied to the liquid chocolate in the test bench of Figure 3A according to an embodiment of the present invention.

[14] Figure 4B is a table depicting the electric field application time versus strength as an electric field is applied to the liquid chocolate in the test bench of Figure 3B according to an embodiment of the present invention.

[15] Figure 4C is a graph depicting the viscosity versus time as an electric field is applied to the liquid chocolate in the test bench of Figure 3B according to an embodiment of the present invention.

[16] Figure 4D is a graph depicting the flow rate versus time as an electric field is applied to the liquid chocolate in the test bench of Figure 3B according to an embodiment of the present invention.

[17] Figure 4E is a graph depicting the viscosity versus time as an electric field is applied to the liquid chocolate in the test bench of Figure 3B according to an embodiment of the present invention.

25 DETAILED DESCRIPTION

[18] The present invention provides methods and systems for reducing the viscosity of liquid chocolate as it is flowing (e.g. through a metal or plastic pipe) or coating a product during production of a chocolate product. Specifically, an electric field is applied along the direction of the flow of the liquid chocolate (e.g. along a direction of a delivery path through the pipe delivering liquid chocolate to a production station that produces chocolate products) at a specified strength and duration in order to aggregate solid particles suspended within the liquid chocolate. As the particles aggregate into streamlined shapes along the flow direction, the viscosity of the liquid chocolate decreases. The size of the streamlined aggregates is controlled by the combination of electric field strength and duration. Embodiments of the methods and systems described herein allow for control of liquid chocolate viscosity without the need to add excess melted fat.

[19] Liquid chocolate is a suspension comprised of solid particles (e.g. sugar particles, cocoa particles, milk particles, etc.) suspended in a liquid that is typically melted fat (e.g. cocoa butter or an equivalent). In general, liquid cocoa butter behaves as a Newtonian fluid. However, with the addition of the suspended particles, the liquid chocolate deviates from Newtonian behavior. In general, the shear stress of the liquid chocolate has pseudo plastic behavior. As shown in Figure 1, the relationship between the shear stress and the shear rate is close to exponential (i.e. it is not linear), and can be modeled by the Casson Model shown in equation 1 below.

$$\sigma^{0.5} = \sigma_0^{0.5} + K_1 \dot{\gamma}^{0.5} \quad (\text{Equation 1})$$

10 where σ is the shear stress, σ_0 is the yield shear stress, $\dot{\gamma}$ is the shear rate and K_1 is a constant. From the Casson model it is found that the viscosity η of liquid chocolate (described in equation 2) decreases as the shear rate increases.

$$\eta = \frac{\sigma}{\dot{\gamma}} \quad (\text{Equation 2})$$

[20] Two characteristics of liquid chocolate is yield shear stress and its viscosity. The value of the yield shear stress is related to the minimum energy required to start the chocolate flowing. If the yield shear stress is high, the chocolate will be thicker and tend to stand up, which may be beneficial for putting on sweets or in producing chocolate morsels for baked cookies, for example. A low yield shear stress may be beneficial to give a thin coating of chocolate over a biscuit, for example.

20 **[21]** In general, viscosity is a measure of resistance of a fluid which is being deformed by either shear or tensile stress. Viscosity determines the size of the pumps needed to pump the liquid chocolate through pipes and determines a coating thickness on a potential chocolate product. If a strong electric field is applied to liquid chocolate in a direction perpendicular to the shear or flow direction (see Figure 2C), then the yield stress and viscosity are increased. As chocolate flows from section 202 in pipe 206 towards section 204, the electrical field applied by electrodes 208 and 210 (e.g. acting as a capacitor) induce the solid particles in the liquid chocolate to align with each other and form solid vertical columns 218 perpendicular to the flow by a dipolar interaction. This effect (i.e. the Winslow effect) increases the viscosity of the liquid chocolate exposed to the electric field and may completely stop the flow of chocolate through pipe 206 (i.e. vertical columns 218 perpendicular to the flow would block the flow from exiting the pipe at 204).

[22] By arranging the electrodes in a manner shown in Figures 2A and 2B, however, an electric field is generated between the electrodes in a direction parallel or anti-parallel (i.e. along the delivery path) to the flow of the chocolate through pipe 206.

The delivery path may be flowing from a vessel which holds the liquid chocolate, through the pipe, to a production station that produces chocolate products at a desired viscosity.

[23] Electrodes 208 and 210 are positioned within pipe 206. In one embodiment (Figure 2A), electrodes 208 and 210 may be metallic meshes (e.g. a pair of grates) that allows the chocolate to flow through the electrodes along the delivery direction of the pipe. In another embodiment (Figure 2B), electrodes 208 and 210 may be metallic rings, which are formed or mounted on the pipe's inner wall. Electrodes 208 and 210 may be electrically connected to an electrical power supply 212 that includes a power source and an electronic controller 232 for applying a voltage potential across electrodes 208 and 210, which results in an electric field between the electrodes. Electrodes 208 and 210 may also be coated with a non-conductive material (e.g. food grade plastic and/or rubber) to prevent the liquid chocolate from coming in direct contact with the electrodes. This coating may be useful in reducing electrical current flowing between the electrodes, and ensuring the integrity of the metallic electrodes over prolonged use.

[24] In general, as the liquid chocolate flows through pipe 206, it has a relatively high viscosity in region 202, including 214. As it flows between electrodes 208 and 210, the solid particles suspended in the liquid chocolate begin to agglomerate into larger stream line aggregates resulting in a reduced viscosity in region 216 and 204.

[25] Specifically, as shown in Figure 2A and Figure 2B, as the liquid chocolate flows from the left to the right along pipe 206, the liquid chocolate passes through the electric field between electrodes 208 and 210. The solid particles suspended in the liquid phase are polarized by the electric field. The induced dipolar interaction forces the particles to temporarily aggregate into short chains or ellipsoids that are along the flow direction. The size of the streamlined shapes may be relatively small (e.g. less than or equal to one hundred micro-meters).

[26] In general, the aggregated chains in Figures 2A and 2B are different from the aggregated chains in Figure 2C, because the aggregated chains in Figures 2A and 2B are small and are arranged along the flow direction of the liquid chocolate. The flow of these streamlined particle aggregates becomes organized in short chains along the pipe direction, so that the apparent viscosity of the liquid chocolate is reduced.

[27] Thus, the relatively high viscosity liquid chocolate on the left side of the pipe in Figure 2A and Figure 2B is agglomerated between electrodes 208 and 210 which produce a liquid chocolate on the right side of pipe 206 having reduced viscosity. The reduced viscosity may gradually increase back to the original viscosity value over a period of time after being exposed to the electrical field.

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[28] In operation, liquid chocolate passes through electrodes 208 and 210 positioned in at least one of a plurality of locations within a delivery pipe (e.g. a metal or plastic vessel) during the manufacture of chocolate products (e.g. candy bars, etc.). An example of chocolate product manufacturing equipment is shown in Fig. 2D where

5 liquid chocolate is pumped from tank 220, through pipe 206 (along delivery path 250) and is applied to candy 246, for example, using applicator 222 to produce a chocolate product 244 (e.g. a chocolate covered candy bar).

[29] Controller 232 (e.g. a microprocessor, a FPGA, a dedicated circuit, etc.) controls an electrical power supply (internal the controller or external (not shown)) to generate

10 and apply the same voltage (e.g. of a predetermined magnitude) or different voltages to the electrode pairs at locations 252 and 254 (via wires 224, 226, 228 and 230). The application of the voltages to the electrodes produces an electric field at a specified polarity along the flow direction (i.e. the delivery path 250) of the liquid chocolate, which changes the viscosity of the liquid chocolate. The magnitude of the voltages

15 applied to the electrodes along with the spacing between the electrodes determines the strength of the electric field.

[30] It is noted that the electric field may be a direct current (DC) or an alternating current (AC) electric field that is applied to the liquid chocolate. It is also noted that the metallic meshes or metallic rings may be of essentially any configuration that

20 provides an electric field along the flow direction of the liquid chocolate while allowing the liquid chocolate to pass along a flow path between the electrodes.

[31] It is noted that the applied electric field is selected to be in a strength range that is conducive to reducing the viscosity of the liquid chocolate. For example, if the electric field strength is too small, reduction in viscosity may be insignificant or may not

25 occur at all. If the electric field strength is too large, the viscosity may actually be increased.

[32] It is noted that the duration of the electric field is also chosen to be in a range that is conducive to reducing the viscosity of the liquid chocolate. In one example, after the applied electric field strength is selected, an appropriate duration of the field

30 application to the liquid chocolate may then be selected. This time duration may be related to the strength of electric field. For example, if the field is first selected to be strong, the duration may then be selected to be short. In another example, the electric field duration may be selected first, and then an appropriate electric field strength may be selected based on the duration. In general, by selecting an appropriate combination

35 of electric field strength and electric field duration, an optimal viscosity reduction for liquid chocolate may be attained.

[33] In one example, controller 232 may be programmed or controlled by an operator to ensure that a predetermined viscosity of the liquid chocolate flowing through pipe 206 is obtained. For example, controller 232 may be programmed to deliver liquid chocolate at a desired viscosity to applicator 222 to ensure that candy
5 246 on assembly line 242 are coated properly to produce desired chocolate products 244. These parameters along with other parameters such as temperature may be utilized by the controller 232 to determine an electric field strength and a duration to obtain a predetermined viscosity of the liquid chocolate that is beneficial for producing chocolate products such as a candy bar.

10 [34] In some products, a thicker chocolate may be desired while in other products, a thinner chocolate may be preferred. Thus, the viscosity of the liquid chocolate may be controlled depending on requirements of the chocolate products.

[35] Sensors (not shown) such as flow rate and/or temperature sensors may be implemented in the pipe to determine the viscosity of the liquid chocolate at one or
15 more locations during the manufacturing process. In another example, the electrical power being consumed by the pump may also be used as an indicator of flow rate and/or viscosity of the chocolate (i.e. high power consumption may indicate high viscosity). This data may then be utilized by the controller 232 to further control the electric field applied to electrodes 208 and 210. For example the liquid chocolate may
20 be maintained below a predetermined viscosity level to ensure proper functioning of the manufacturing equipment.

[36] It is shown in Fig. 2D that the controller may communicate (i.e. receive and/or transmit information) to control various pieces of equipment in the manufacturing process using one or more control lines. These (wired or wireless) control lines may
25 include, but are not limited to, chocolate applicator line 234, conveyor belt line 236, operator interface line 237, pump line 238, sensor line 240 and/or valve line 241.

[37] In one example, the controller may control the production equipment by controlling the electric field applied to the liquid chocolate, pumps pumping the liquid chocolate through the pipe, applicators applying the liquid chocolate to the candy
30 products, conveyor belts moving candy for application of liquid chocolate, heating devices heating the liquid chocolate, sensors for detecting various characteristics of the liquid chocolate (e.g. temperature, flow rate, viscosity, etc.), valves for allowing the liquid chocolate to flow through pipes and applicators, valves for mixing ingredients (e.g. melted fat) into the liquid chocolate and a user interfaces for interfacing (i.e.
35 inputting and outputting information) to an operator.

[38] Figure 3A is a test bench setup that was utilized to test the viscosity of liquid chocolate in the presence of an electric field. As shown in Figure 3A, a heating surface

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306 maintains the chocolate in a liquid form. The liquid chocolate 308 is then forced through metallic meshes 310 and 312 by a weight 302 and piston 304. As the liquid chocolate 308 is forced between electrodes 310 and 312, it is exposed to an electric field if a voltage is applied to the electrodes and its viscosity is reduced (i.e. its flow rate is increased if an electric field of a desired strength and duration is applied). The liquid chocolate with low viscosity is then collected in a container 314. The flow rate is then measured by a computer 318 connected to a balance 316.

[39] In one experiment, the liquid chocolate is maintained around 40°C utilizing heating surface 306. Under gravity, the liquid chocolate flowed through the metallic meshes 310 and 312 which applied a predetermined electric field in the flow direction of the chocolate. The balance 316 measured the liquid chocolate's mass as a function of time. This allowed the flow rate through pipe 320 to be determined.

[40] Figure 4A shows a graph of the flow rate of the liquid chocolate (402, 404, 406, 408 and 410) versus time for the test bench in Figure 3A. For the data in Figure 4A, there was no additional weight applied. The liquid chocolate first flowed down through the pipe without any electric field being applied. The flow rate was approximately 0.0106 g/s (see 402) indicating that the viscosity of the liquid chocolate is about 41.3 Pa.s. After an electric field of 575 V/cm was applied, the flow rate was increased to 0.01798 g/s (see 404) which reduced the viscosity to 24.46 Pas. (i.e. a 41% decrease in viscosity after being exposed to the electric field). In this experiment, the liquid chocolate took approximately 1 minute to flow by the two electrodes and into container 314.

[41] After 10 minutes, the electric field was turned off, and the flow rate began to decrease indicating that the reduced viscosity gradually returned to its original value (i.e. see data 406, 408 and 410 where the flow rate gradually decreases over time after the electric field has been turned off). In other experiments, the electric field was reapplied to the liquid chocolate and the viscosity reduction was repeated.

[42] Figure 3B is another test bench similar to the test bench in Figure 3A. However, the test bench in Figure 3B uses pressurized gas (not a weight) to force the liquid chocolate through pipe 320. Also, the test bench in Figure 3B is located inside an incubator 328 to keep the chocolate at a desired temperature. Heating surface 306 is therefore not needed in this test bench.

[43] In general, pressurized gas (e.g., nitrogen) under control of computer 318 is applied to liquid chocolate 308 through pipe 322. In response to the applied pressure, liquid chocolate 308 is forced through electrified meshes 310/312, through tube 320 and into container 314 where its weight is measured by balance 316. The test bench in

Figure 3B also may include a temperature sensor 326 that allows the computer to monitor the temperature of the liquid chocolate during the testing process.

[44] Figure 4B shows the relationship between the application time of the electric field and the optimal electric field strength for the test bench in Figure 3B. In general, as the application time increases, the strength of the electric field decreases (i.e., the longer it takes for the chocolate to flow through the electric field, the lower the electric field strength needs to be). This inverse relationship is shown in rows 412, 414, 416, 418, 420 and 422 of the table in Figure 4B.

[45] Figure 4C shows a graph of the viscosity of the liquid chocolate (424 and 426) versus time for the test bench in Figure 3B. In one example, (corresponding to row 414 in Figure 4B) a chocolate sample at 40°C took 9.37 seconds to flow through an electric field with a strength of 1838 V/cm. In this example, the viscosity was reduced from 43.23 Pa.s (see 424) to 29.53 Pa.s (see 426). This particular electric field application produced a 31.7% reduction in viscosity.

[46] For tempered chocolate, it was found that the electric field needed to be slightly higher. In general, to temper chocolate, solid chocolate is shaved. To produce fine shavings, a mesh is used to filter the particles. Solid chocolate with diameter less than a set size (e.g., 150 micro-meters) are used as seeds. About 1kg chocolate was melted at 40°C and cooled down to 30°C. After 10g fine solid chocolate was mixed, the experiment using the test bench began. It is noted that the viscosity of the tempered chocolate increases very fast. It solidifies in about 30 minutes. Within this period, however, an electric field may be applied to reduce its viscosity.

[47] Figures 4D and 4E show graphs of flow rate (428, 430, 432, 434, 436, 438 and 440) and viscosity (442, 444, 446, 448, 450, 452 and 454) versus time respectively for the tempered chocolate. As shown in Figure 4D, nine minutes after the mixing, the flow rate was 0.477545 g/s (see 428) under 1.56 Psi of pressure. When the electric field 1.2kV/cm was turned on, the flow rate increased to 0.584745 g/s (see 430) (an increase of 22.45%). After 100 seconds of electric field application, the electric field was turned off and the corresponding flow rate was 0.465407 g/s (see 432). The flow rate was measured every 30 seconds thereafter. In about 180 seconds, the flow rate decreased to 0.33801 g/s (see 440) (reduced by 27.3%). This indicated that the tempered chocolate was solidifying.

[48] From the flow rate, it was found that the viscosity (see Fig. 4E) was about 121.82 Pa.s (see 442) at nine minutes after the mixing. When an electric field of 1.2 kV/cm was applied, the viscosity was down to 99.487 Pa.s (see 444). After the electric field was turned off, the viscosity was 125.0 Pa.s (see 446). In another three minutes, the viscosity was increased to 172.1 Pa.s (see 454).

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[49] It is noted that the inventors have discovered that a suitable range for the electric field is from 100 V/cm to 6000V/cm, and works particularly well in the range of 500 V/cm to 800 V/cm for some types of chocolate (e.g. Milk Chocolate available from Hershey of Hershey Pennsylvania). If the electric field applied is too weak, there may
5 be no noticeable viscosity reduction. On the other hand, if the applied electric field is too strong, the viscosity may actually increase. Because the liquid chocolate has a strong electrorheological effect (ER) the solid structure aggregates may become too large if exposed to an electrical field that is too strong, which would lead to increased viscosity (i.e. if the aggregates increase from micro-meter size to a larger macro-scopic
10 size).

[50] As described above, the duration of the electric field may be chosen based on the selected strength of the electric field (i.e. if the field is stronger, then the duration may be shortened) or visa versa. It is also noted that the duration of the electric field applied to liquid chocolate is equal to the time for the liquid chocolate to pass through
15 the electric field. This duration can be changed if needed by adjusting the flow rate of the liquid chocolate (e.g. increasing/decreasing pump power), and/or by increasing/decreasing the gap between the two electrodes. By selecting a combination of an electric field strength and a duration of the field, viscosity reduction can be optimized for the flow of liquid chocolate through a pipe. It is furthermore noted that
20 the electric current flowing between the meshes in the test benches was found to be very small (e.g., a couple of micro amperes). This indicates that the system is energy efficient while reducing the viscosity of the chocolate.

[51] Although the invention is illustrated and described herein with reference to specific embodiments, the invention is not intended to be limited to the details shown.
25 Rather various modifications may be made in the details within the scope and range of equivalence of the claims and without departing from the invention.

CLAIMS

1. A method for producing a chocolate product, the method comprising:
delivering liquid chocolate having a viscosity through a pipe along a delivery
path to a production station for producing the chocolate product, the liquid chocolate
5 including solid particles suspended within the liquid chocolate; and
changing the viscosity of the liquid chocolate by applying an electric field to the
liquid chocolate in a direction along the delivery path of a strength and duration
determined to aggregate the suspended solid particles into streamlined shapes
extending along the direction of the delivery path.
- 10 2. The method of claim 1, wherein changing the viscosity comprises:
applying the electric field in a strength range of 300V/cm to 1000V/cm.
3. The method of claim 1,
wherein the liquid chocolate comprises melted fat and the solid particles
suspended in the melted fat, and
- 15 wherein the suspended solid particles include at least one of sugar particles,
cocoa particles or milk particles.
4. The method of claim 1, further comprising:
determining the strength and duration for applying the electric field to the liquid
chocolate based on a predetermined consistency of the chocolate product.
- 20 5. The method of claim 1, further comprising:
determining the strength and duration for applying the electric field to the liquid
chocolate based on a predetermined fat content of the chocolate product.
6. The method of claim 1, further comprising:
determining the strength and duration for applying the electric field to the liquid
25 chocolate based on a type of chocolate used in the production of the chocolate product.
7. The method of claim 1,
controlling the strength and duration for applying the electric field based on the
determined flow rate of the liquid chocolate along the delivery path.
8. The method of claim 1,
30 controlling the strength and duration for applying the electric field based on the
determined viscosity of the liquid chocolate along the delivery path.
9. The method of claim 1,
tempering the liquid chocolate prior to delivering the liquid chocolate through
the pipe.
- 35 10. A system for producing a chocolate product, the system comprising:

a chocolate delivery pipe for flowing liquid chocolate having a viscosity along a delivery path to a production station for producing the chocolate product, the liquid chocolate including solid particles suspended in the liquid chocolate; and

at least two electrodes integrated into the chocolate delivery pipe for changing
5 the viscosity of the liquid chocolate by applying an electric field to the liquid chocolate in a direction along the delivery path of a strength and duration determined to aggregate the solid particles into streamlined shapes extending along the direction of the delivery path.

11. The system of claim 10,
10 wherein the at least two electrodes are metallic meshes coupled to a pair of respective output terminals of an electric power supply that produce the electric field.

12. The system of claim 10,
wherein the at least two electrodes are metallic rings coupled to a pair of respective output terminals of an electric power supply that produce the electric field.

15 13. The system of claim 10, further comprising
a controller coupled to the at least two electrodes to control the strength and duration of the electric field applied to the liquid chocolate to reduce the viscosity to a predetermined level.

14. The system of claim 10, further comprising
20 a controller, and
wherein the controller controls a flow rate of the liquid chocolate to adjust the duration during which the electric field is applied to the liquid chocolate.

15. The system of claim 10, wherein
the electrodes are spaced to produce a gap between the electrodes, and
25 the gap is adjusted to control the duration during which the electric field is applied to the liquid chocolate.

16. The system of claim 10, further comprising
a source of melted fat; and
a controller controlling an amount of melted fat included in the liquid chocolate
30 based on the electric field.

17. The system of claim 10, further comprising
a sensor located in the chocolate delivery pipe for measuring a flow rate or viscosity of the liquid chocolate.

18. The system of claim 17, further comprising
35 a pump for pumping the liquid chocolate through the chocolate delivery pipe, a speed of the pump being controlled based on a signal received from the sensor located in the chocolate delivery pipe.

19. A system for producing a chocolate covered candy product, the method comprising:

a chocolate delivery pipe and a pump for flowing liquid chocolate having a viscosity along a delivery path to an applicator, the liquid chocolate including solid
5 particles suspended in the liquid chocolate, the applicator applying the liquid chocolate to a candy product to produce the chocolate covered candy product;

at least two electrodes integrated into the chocolate delivery pipe for changing the viscosity of the liquid chocolate by applying an electric field to the liquid chocolate in a direction along the delivery path to the applicator of a strength and duration to
10 aggregate the suspended solid particles into streamlined shapes extending along the direction of the delivery path; and

a controller for controlling the strength of the electric field, the duration of the electric field and a pumping speed of the pump to supply liquid chocolate at a predetermined viscosity to the applicator.

15 20. The system of claim 19, further comprising

at least two other electrodes integrated into the chocolate delivery pipe for changing the viscosity of the liquid chocolate by applying another electric field to the liquid chocolate in a direction along the delivery path to the applicator.

21. The system of claim 19, further comprising

20 sensors integrated into the chocolate delivery pipe for sensing a flow rate or a viscosity of the liquid chocolate.

22. The system of claim 19, wherein

the controller determines a flow rate or a viscosity of the liquid chocolate based on electric power consumption of the pump.

25 23. The system of claim 19, wherein

the liquid chocolate is pumped from a liquid chocolate tank and the controller controls mixing of the liquid chocolate in the tank based on the predetermined viscosity.

24. The system of claim 19, wherein

30 the controller includes an operator interface having an input and a display for an operator of the system to manually control the flow rate or viscosity of the liquid chocolate.

25. The system of claim 19, wherein

35 the at least two electrodes are metallic electrodes coated with non-conductive food grade plastic.

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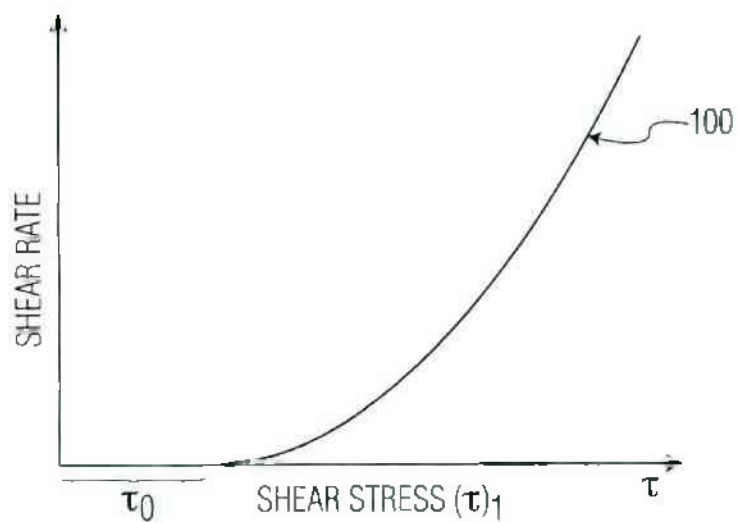


FIG. 1

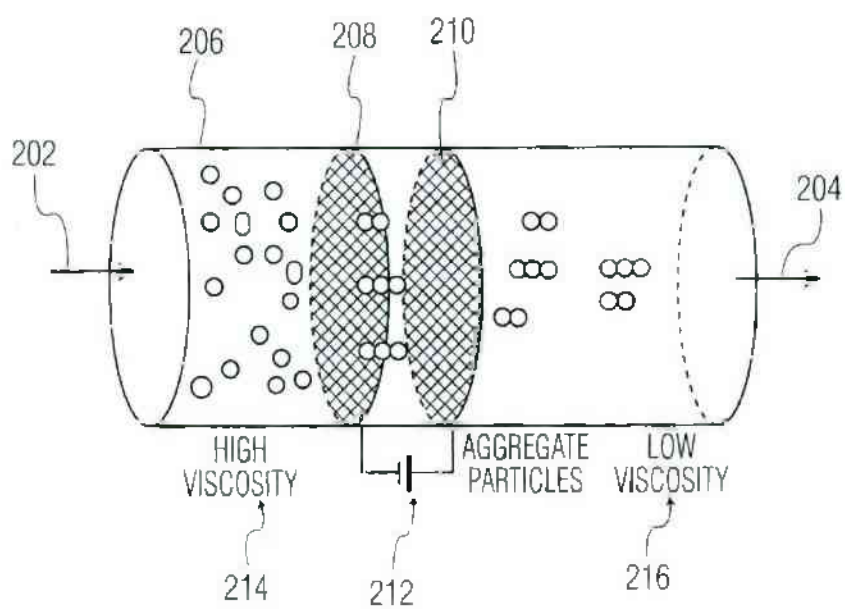


FIG. 2A

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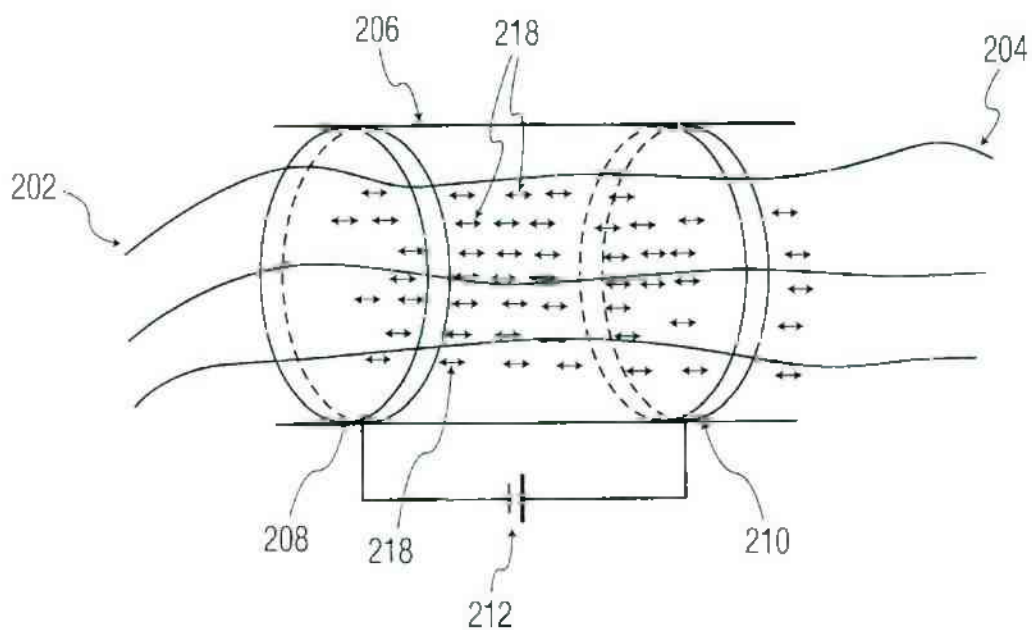


FIG. 2B

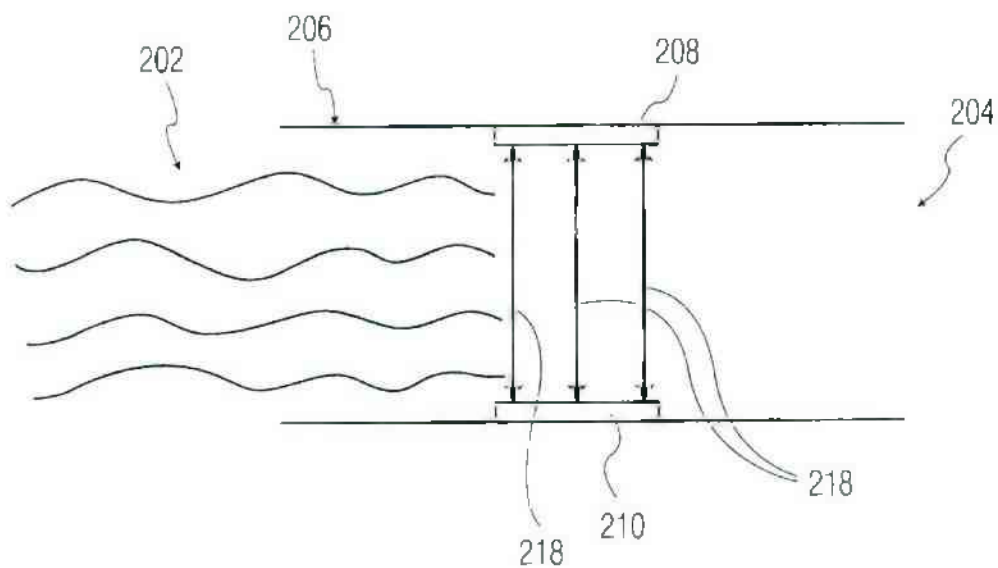


FIG. 2C

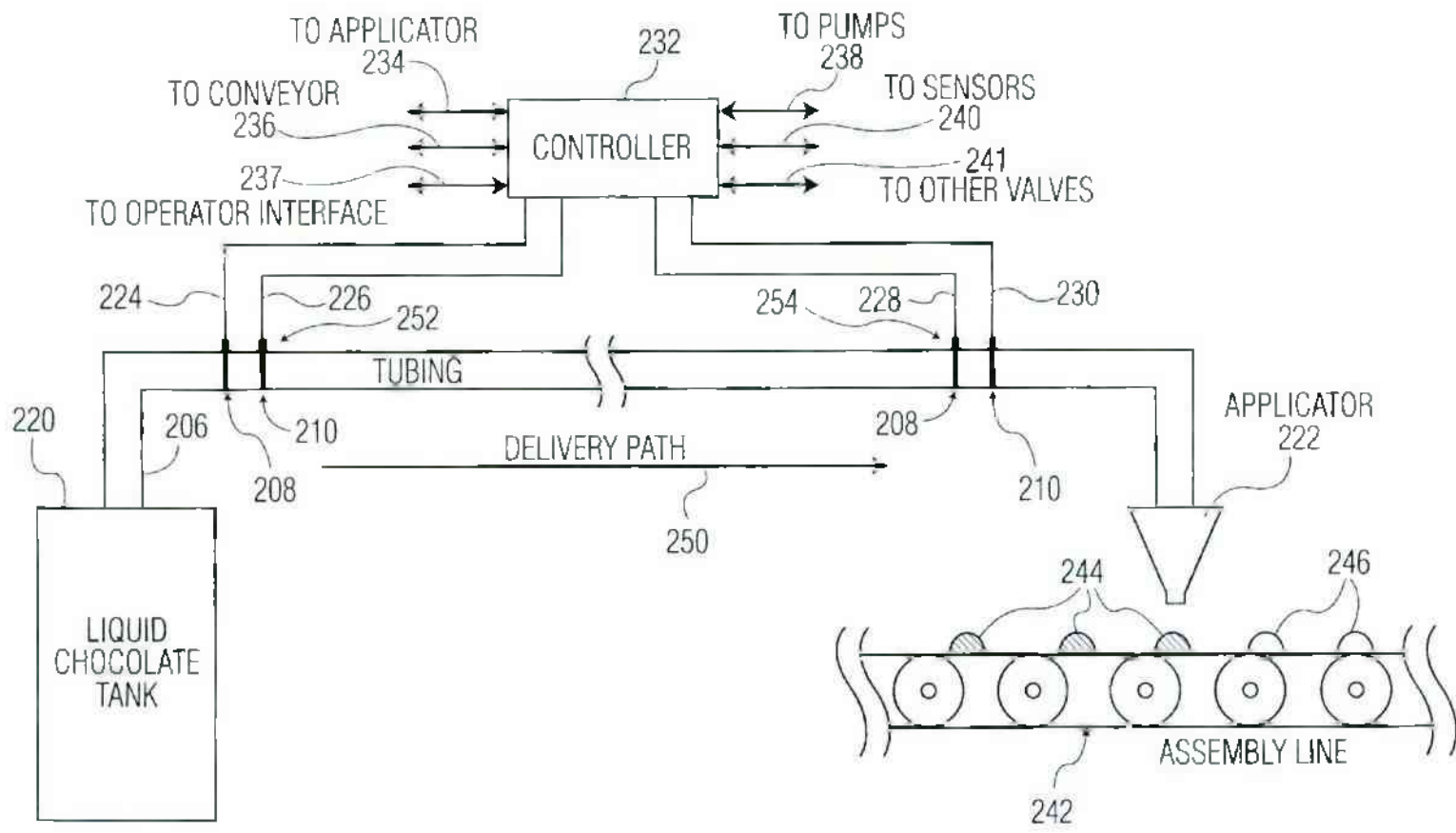


FIG. 2D

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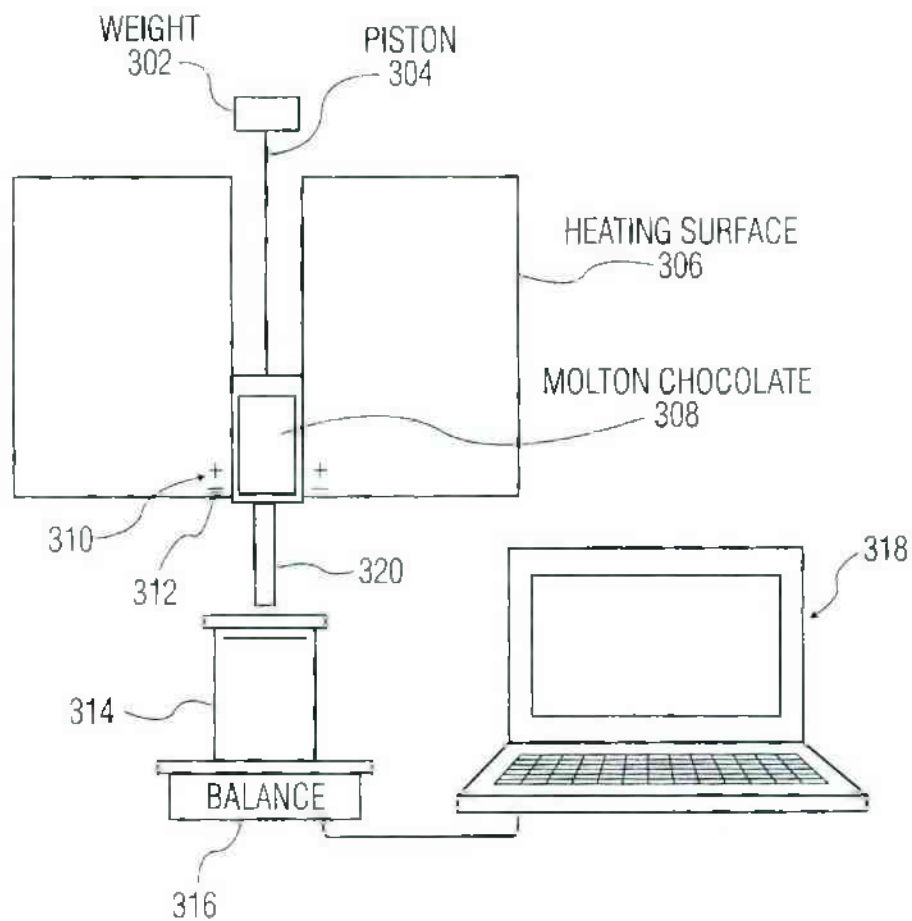


FIG. 3A

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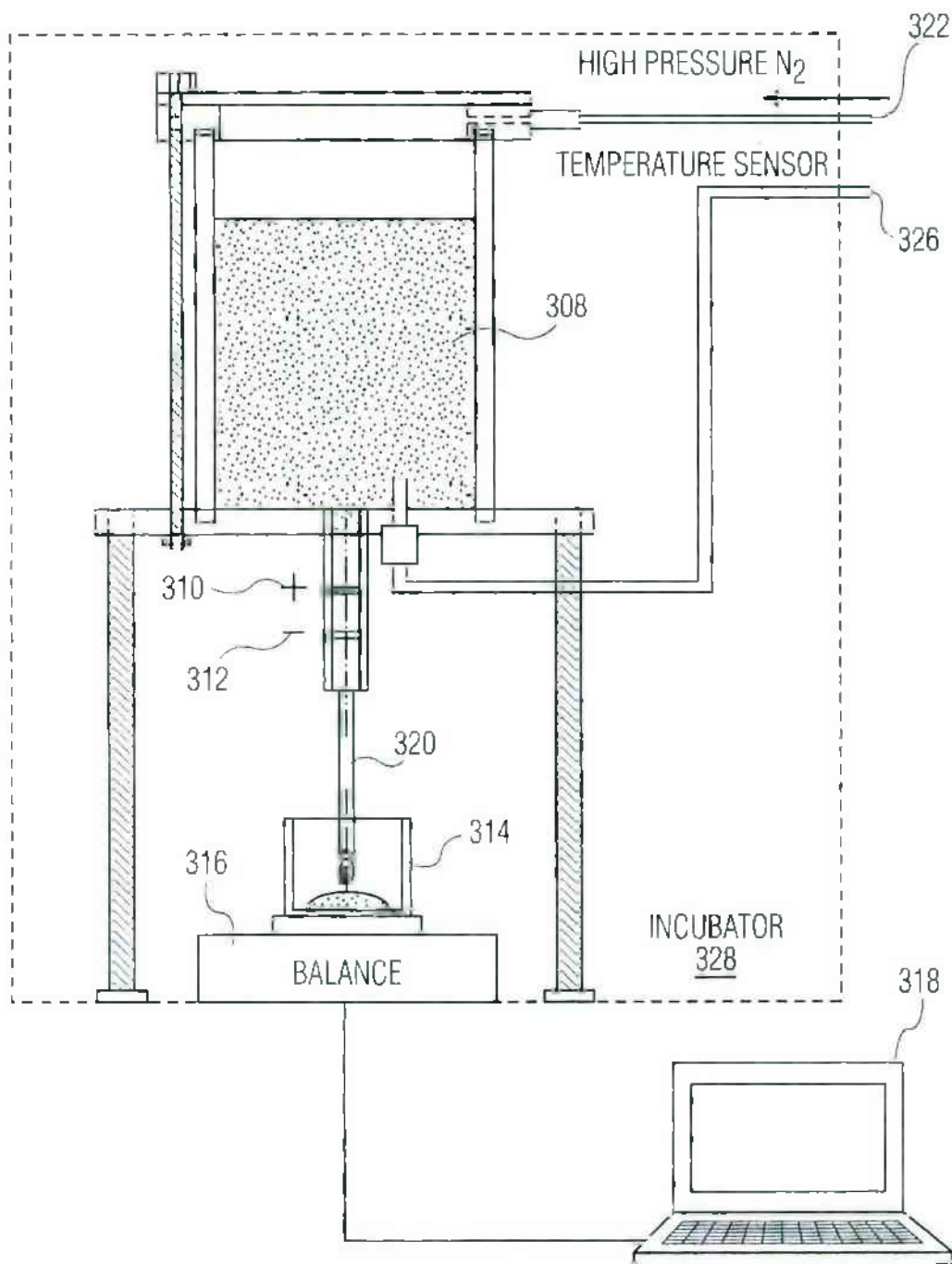


FIG. 3B

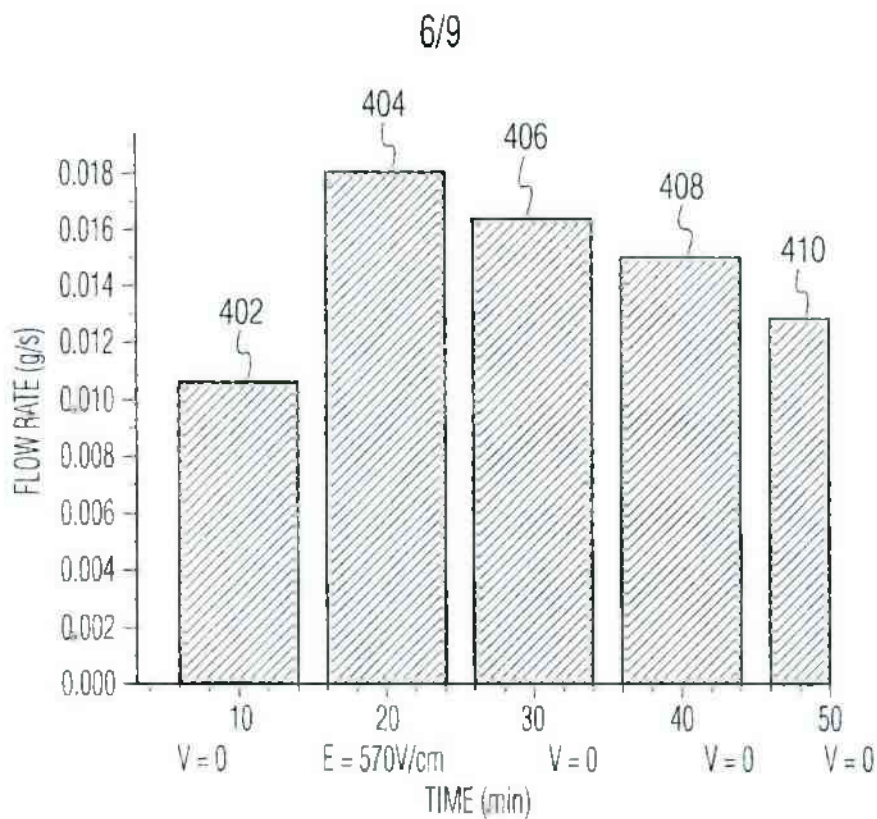


FIG. 4A

	TIME FOR THE CHOCOLATE FLOW TO PASS THE ELECTRIC FIELD (S)	OPTIMAL ELECTRICAL FIELD (V/cm)
412	5.0	2517
414	9.37	1838
416	13.7	1520
418	19.0	1291
420	24.2	1144
422	39.3	898

FIG. 4B

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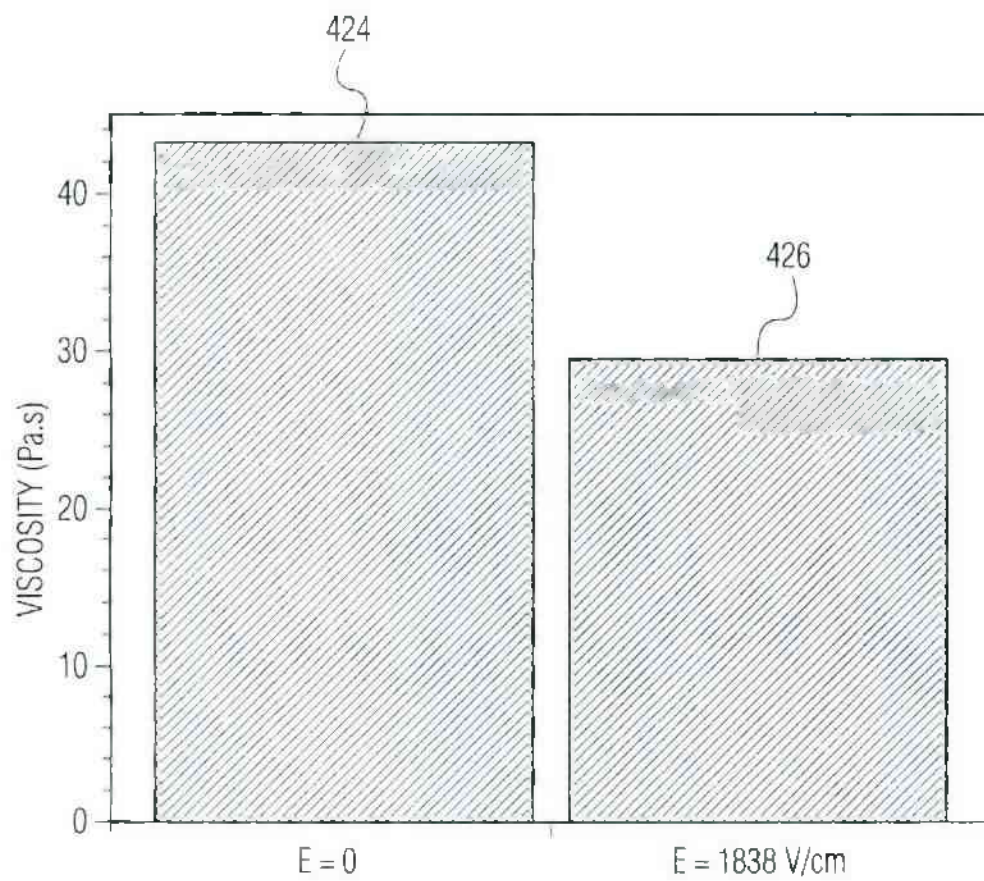


FIG. 4C



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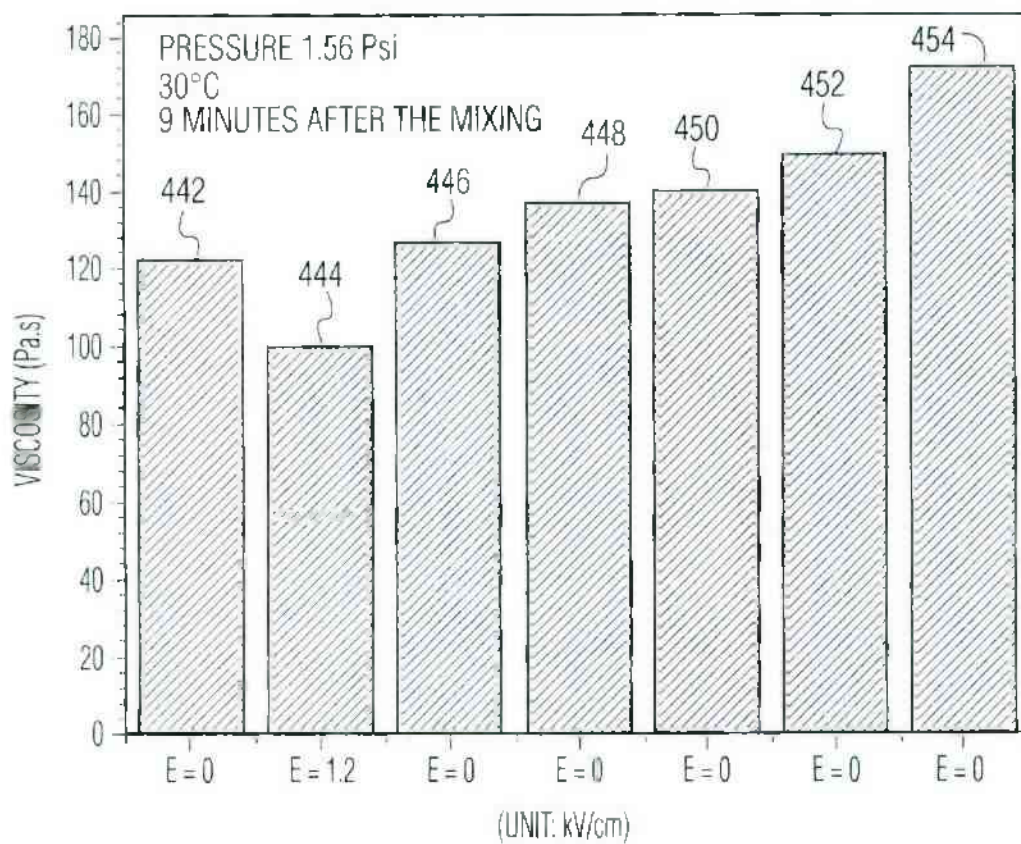


FIG. 4E

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/023988**A. CLASSIFICATION OF SUBJECT MATTER**

A23G 1/04(2006.01); A23G 1/50(2006.01);

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A23G 1/04, A23G 1/50

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: chocolate electric field electrode candy viscosity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010-012032 A1 (CAVITUS PTY LTD et al.) 04 February 2010 See page 7, lines 29-32, page 12, lines 13-15, page 13, lines 5-6, page 13, lines 3-4, page 24, lines 10-11; claims 1, 18; figures 2, 9.	1-25
A	US 04208440 A (SCHMIDT; EDWARD D.) 17 June 1980 See column 2, lines 30-53; claim 1.	1-25
A	US 2004-0013776 A1 (ANDREW STEVE WHITEHOUSE et al.) 22 January 2004 See claims 1, 3, 6, 13.	1-25
A	US 2011-0217432 A1 (KRNIC PETER et al.) 08 September 2011 See abstract; claims 6-8, 16.	1-25
A	US 05032588 A (CAPODIECI; ROBERTO A.) 26 July 1994 See abstract; claims 19, 29.	1-25
A	US 05676995 A (CULLY; KEVIN JOHN et al.) 14 October 1997 See abstract; column 3, lines 3-9; claim 1.	1-25

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 June 2013 (17.06.2013)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

Korean Intellectual Property Office
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/023988

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MÉTODO Y EQUIPO PARA LA PRODUCCIÓN DE CHOCOLATE REFERENCIA CRUZADA A APLICACIONES RELACIONADAS

[1] Esta aplicación reclama prioridad a la Aplicación provisional de los EE.UU. N° 61/592,648, presentada el 31 de enero de 2012. Los contenidos de la Aplicación provisional de los EE.UU. N° 61/592,648 se incorporan en la presente por referencia.

CAMPO

[2] El presente invento se refiere a los métodos y al equipo de producción de chocolate.

RESUMEN

[3] El presente invento se refiere a un método y a un equipo para producir un producto de chocolate. El método incluye el suministrar un chocolate líquido con cierta viscosidad a través de una tubería a lo largo de una vía de suministro a una estación de producción para producir un producto de chocolate. El chocolate líquido incluye partículas sólidas suspendidas en el chocolate líquido. El método cambia la viscosidad del chocolate líquido mediante la aplicación de un campo eléctrico al chocolate líquido en una dirección a lo largo de la vía de suministro para agregar las partículas sólidas suspendidas en formas aerodinámicas colocadas en cadenas cortas que se extienden en la dirección de la vía de suministro.

ANTECEDENTES

[4] El chocolate contiene antioxidantes y por lo tanto puede proporcionar beneficios a la salud. Los productos de chocolate convencionales contienen un exceso de grasa lo que puede causar problemas de salud tales como obesidad. De hecho, la mayoría de los productos de chocolate contienen entre un 25 y un 35% de contenido en grasa.

[5] En general, el chocolate líquido usado para fabricar productos de chocolate incluye un exceso de grasa derretida (por ej. manteca de cacao) que se añade a propósito al chocolate líquido con el propósito de reducir la viscosidad para fines de fabricación. Este exceso de grasa derretida se usa porque incluso a la temperatura de fusión, la viscosidad del chocolate líquido puede ser demasiado alta para la fabricación. Por consiguiente, queda que se añada una cantidad de grasa dañina al chocolate líquido con el fin de reducir la viscosidad durante la fabricación.

DESCRIPCIÓN BREVE DE LAS FIGURAS

[6] La figura 1 es una gráfica que representa la relación entre la fuerza de corte y la velocidad de corte para el chocolate líquido según una encarnación del presente invento.

[7] La figura 2A es una vista lateral de la aplicación de un campo eléctrico al chocolate líquido mientras fluye a través de una tubería según una encarnación del presente invento.

[8] La figura 2B es una vista lateral de un campo eléctrico aplicado al chocolate líquido mientras fluye a través de una tubería según otra encarnación del presente invento.

[9] La figura 2C es una vista lateral de columnas sólidas formadas perpendiculares al flujo del chocolate líquido dentro de la tubería según una encarnación del presente invento.

[10] La figura 2D es una vista lateral de un equipo de fabricación de un producto de chocolate aplicando un campo eléctrico al chocolate líquido según una encarnación del presente invento.

[11] La figura 3A es un diagrama de sistema de un banco de pruebas utilizado para medir la velocidad de flujo del chocolate líquido cuando se aplica un campo eléctrico según una encarnación del presente invento.

[12] La figura 3B es un diagrama de sistema de otro banco de pruebas utilizado para medir la velocidad de flujo del chocolate líquido cuando se aplica un campo eléctrico según una encarnación del presente invento.

[13] La figura 4A es una gráfica que describe la velocidad de flujo en función del tiempo cuando se aplica un campo eléctrico al chocolate líquido en el banco de pruebas de la figura 3A según una encarnación del presente invento.

[14] La figura 4B es una tabla que describe el tiempo de aplicación de un campo eléctrico frente a la fuerza cuando se aplica un campo eléctrico al chocolate líquido en el banco de pruebas de la figura 3B según una encarnación del presente invento.

[15] La figura 4C es una gráfica que describe la viscosidad en función del tiempo cuando se aplica un campo eléctrico al chocolate líquido en el banco de pruebas de la figura 3B según una encarnación del presente invento.

[16] La figura 4D es una gráfica que describe la velocidad de flujo en función del tiempo cuando se aplica un campo eléctrico al chocolate líquido en el banco de pruebas de la figura 3B según una encarnación del presente invento.

[17] La figura 4E es una gráfica que describe la viscosidad en función del tiempo cuando se aplica un campo eléctrico al chocolate líquido en el banco de pruebas de la figura 3B según una encarnación del presente invento.

DESCRIPCIÓN DETALLADA

[18] El presente invento proporciona métodos y sistemas para reducir la viscosidad del chocolate líquido mientras fluye (por ej. a través de una tubería de metal o de plástico) o baña un producto durante la producción de un producto de chocolate. Específicamente, se aplica un campo eléctrico a

lo largo de la dirección del flujo del chocolate líquido (por ej. a lo largo de una dirección de la vía de suministro a través del tubo que suministra el chocolate líquido a una estación de producción que produce productos de chocolate) a una fuerza especificada y durante un tiempo especificado para agregar partículas sólidas suspendidas en el chocolate líquido. A medida que las partículas se agregan en formas aerodinámicas a lo largo de la dirección de flujo, la viscosidad del chocolate líquido disminuye. El tamaño de los agregados aerodinámicos se controla con una combinación de la fuerza y duración del campo eléctrico. Las encarnaciones de los métodos y sistemas descritos en la presente permiten controlar la viscosidad del chocolate líquido sin tener que añadir un exceso de grasa derretida.

[19] El chocolate líquido es una suspensión que comprende partículas sólidas (por ej. partículas de azúcar, partículas de cacao, partículas de leche, etc.) suspendidas en un líquido que es típicamente grasa derretida (por ej. manteca de cacao o un equivalente). En general, la manteca de cacao se comporta como un fluido newtoniano. Sin embargo, con la adición de las partículas en suspensión, el chocolate líquido se desvía de su comportamiento newtoniano. En general la tensión de corte del chocolate líquido tiene un comportamiento pseudo plástico. Según muestra la figura 1, la relación entre la fuerza de corte y la velocidad de corte se aproxima a una relación exponencial (es decir no es lineal) y se puede modelar de acuerdo con el modelo Casson que se muestra en la ecuación 1 a continuación.

$$\sigma^{0.5} = \sigma_0^{0.5} + K_1 (\dot{\gamma})^{0.5} \quad (\text{Ecuación 1})$$

donde σ es la fuerza de corte, σ_0 es el límite de fluencia de corte, $\dot{\gamma}$ es la velocidad de corte y K_1 es una constante. Del modelo de Casson se deduce que la viscosidad η del chocolate líquido (descrita en la ecuación 2) disminuye cuando la velocidad de corte aumenta.

$$\eta = \frac{\sigma}{\dot{\gamma}} \quad (\text{Ecuación 2})$$

[20] Dos características del chocolate líquido son el límite de fluencia de corte y su viscosidad. El valor del límite de fluencia de corte está relacionado con la menor cantidad de energía requerida para hacer que el chocolate empiece a fluir. Si el límite de fluencia de corte es alto, el chocolate será más espeso y tenderá a levantarse, lo que puede ser beneficioso para poner en dulces o para producir pedazos de chocolate para galletas horneadas, por ejemplo. Un límite de fluencia de corte bajo puede ser beneficioso para dar un baño de chocolate delgado sobre una galleta, por ejemplo.

[21] En general, la viscosidad es una medida de la resistencia de un fluido que se está deformando bien por la fuerza de corte o por la fuerza de tensión. La viscosidad determina el tamaño de las bombas que se necesitan para bombear el chocolate líquido a través de las tuberías y determina el espesor de baño en un posible producto de chocolate. Si se aplica un campo eléctrico fuerte al chocolate líquido en una dirección perpendicular a la dirección de corte o del flujo (vea la figura 2C), entonces aumentan el límite de fluencia y la viscosidad. A medida que el chocolate fluye de la

sección 202 en la tubería 206 hacia la sección 204, el campo eléctrico aplicado por los electrodos 208 y 210 (por ejemplo actuando como capacitador) induce a las partículas sólidas en el chocolate a alinearse unas con otras y formar columnas verticales sólidas 218 perpendiculares al flujo por una interacción bipolar. Este efecto (es decir, el efecto Winslow) aumenta la viscosidad del chocolate líquido expuesto al campo eléctrico y puede detener completamente el flujo del chocolate a través de la tubería 206 (es decir, las columnas verticales 218 perpendiculares al flujo bloquearían el flujo impidiendo que saliese de la tubería en 204).

[22] Al colocar los electrodos en la manera que se muestra en las figuras 2A y 2B, sin embargo, se genera un campo eléctrico entre los electrodos en una dirección paralela o anti paralela (es decir a lo largo de la vía de suministro) al flujo del chocolate a través de la tubería 206. La vía de suministro puede que esté fluyendo desde una vasija que contiene el chocolate líquido, a través de una tubería, a una estación de producción que produce productos de chocolate a la viscosidad deseada.

[23] Los electrodos 208 y 210 están colocados dentro de la tubería 206. En una encarnación (figura 2A), los electrodos 208 y 210 pueden ser mallas metálicas (por ej. un par de rejillas) que permiten que el chocolate fluya a través de los electrodos a lo largo de la dirección de suministro de la tubería. En otra encarnación (figura 2B), los electrodos 208 y 210 pueden ser anillos metálicos, formados o montados en la pared interior de la tubería. Los electrodos 208 y 210 pueden estar conectados eléctricamente a una fuente de energía eléctrica 212 que incluye una fuente de energía y un controlador eléctrico 232 para aplicar un potencial de voltaje a través de los electrodos 208 y 210, lo que resulta en un campo eléctrico entre los electrodos. Los electrodos 208 y 210 también se pueden recubrir con un material no conductor (por ej. plástico de grado alimenticio y/o goma) para impedir que el chocolate líquido entre en contacto directo con los electrodos. Este recubrimiento puede ser útil para reducir la corriente eléctrica que fluye entre los electrodos y para asegurar la integridad de los electrodos metálicos durante un uso prolongado.

[24] En general, a medida que el chocolate líquido fluye a través de la tubería 206, tiene una viscosidad relativamente alta en la región 202, incluyendo 214. A medida que fluye entre los electrodos 208 y 210, las partículas sólidas suspendidas en el chocolate líquido empiezan a aglomerarse en agregados aerodinámicos más grandes lo que resulta en una viscosidad reducida en la región 216 y 204.

[25] Específicamente, como se muestra en la figura 2A y figura 2B, a medida que el chocolate líquido fluye de izquierda a derecha a lo largo de la tubería 206, el chocolate líquido pasa a través del campo eléctrico entre los electrodos 208 y 210. El campo eléctrico polariza las partículas sólidas suspendidas en la fase líquida. La interacción dipolar inducida fuerza las partículas a agregarse temporalmente en cadenas cortas o elipsoides que están a lo largo de la dirección de flujo. El tamaño de las formas aerodinámicas puede ser relativamente pequeño (por ej. menor o igual a cien micrómetros).

[26] En general, las cadenas agregadas en las figuras 2A y 2B son diferentes de las cadenas agregadas en la figura 2C porque las cadenas agregadas en las figuras 2A y 2B son más pequeñas y

están colocadas a lo largo de la dirección de fluido del chocolate líquido. El flujo de estos agregados de partículas aerodinámicas se organiza en cadenas cortas a lo largo de la tubería, de manera que se reduce la viscosidad aparente del chocolate líquido.

[27] De este modo, el chocolate líquido con una velocidad relativamente alta del lado izquierdo de la tubería en la figura 2A y de la figura 2B se aglomera entre los electrodos 208 y 210 lo que produce un chocolate líquido en el lado derecho de la tubería 206 con una viscosidad reducida. La viscosidad reducida puede aumentar gradualmente hasta alcanzar el valor de viscosidad original a lo largo de un período de tiempo después de haber estado expuesto al campo eléctrico.

[28] Cuando está en funcionamiento, el chocolate líquido pasa a través de los electrodos 208 y 210 colocados en al menos una de una pluralidad de ubicaciones en una tubería de suministro (por ej. una vasija metálica o de plástico) durante la fabricación de los productos de chocolate (por ej. barras de golosinas, etc.). Un ejemplo de un equipo de fabricación de productos de chocolate se muestra en la figura 2D en el que el chocolate líquido se bombea desde un tanque 220, a través de una tubería 206 (a lo largo de la vía de suministro 250) y se aplica a la golosina 246, por ejemplo, usando un aplicador 222 para producir un producto de chocolate 244 (por ej. una barra de golosina cubierta con chocolate).

[29] El controlador 232 (por ej. un microprocesador, un FPGA, un circuito dedicado, etc.) controla una fuente de energía eléctrica (interna, el controlador o externa (no se muestra)) para generar y aplicar el mismo voltaje (por ej. de una magnitud predeterminada) o voltajes diferentes a los pares de electrodos en las ubicaciones 252 y 254 (vía los cables 224, 226, 228 y 230). La aplicación de los voltajes a los electrodos produce un campo eléctrico a una polaridad especificada a lo largo de la dirección de flujo (por ej. la vía de suministro 250) del chocolate líquido, que cambia la viscosidad del chocolate líquido. La magnitud de los voltajes aplicados a los electrodos junto con la separación entre los electrodos determina la fuerza del campo eléctrico.

[30] Se hace notar que el campo eléctrico puede ser un campo eléctrico de corriente continua (CC) o de corriente alterna (CA) que se aplica al chocolate líquido. También se hace notar que las mallas metálicas o los anillos metálicos pueden ser esencialmente de cualquier configuración que proporciona un campo eléctrico a lo largo de la dirección de fluido del chocolate líquido con tal de que permita que el chocolate líquido pase a lo largo de una vía de flujo entre los electrodos.

[31] Se hace notar que el campo eléctrico aplicado se selecciona para que sea en un rango de fuerza conducente a reducir la viscosidad del chocolate líquido. Por ejemplo, si la fuerza del campo eléctrico es demasiado pequeña, la reducción en la viscosidad puede ser insignificante o puede que no se produzca. Si la fuerza del campo eléctrico es demasiado grande, la viscosidad puede incluso aumentar.

[32] Se hace notar que la duración del campo eléctrico también se elige para que esté en un rango conducente a reducir la viscosidad del chocolate líquido. En un ejemplo, después de que se seleccionó la fuerza del campo eléctrico aplicado, se puede entonces seleccionar una duración

adecuada de la aplicación del campo al chocolate líquido. Este tiempo de duración puede estar relacionado a la fuerza del campo eléctrico. Por ejemplo, si primero se selecciona que el campo sea fuerte, se puede, entonces, seleccionar una duración corta. En otro ejemplo, la duración del campo eléctrico se puede seleccionar primero y, después, se puede seleccionar una fuerza del campo eléctrico adecuada basada en la duración. En general, seleccionando una combinación adecuada de fuerza del campo eléctrico y duración del campo eléctrico, se puede obtener una reducción óptima de la viscosidad del chocolate líquido.

[33] En un ejemplo, un operador puede programar o controlar el controlador 232 para asegurar que se obtiene una viscosidad predeterminada del chocolate líquido que fluye a través de la tubería. Por ejemplo, el controlador 232 puede ser programado para suministrar chocolate líquido a una viscosidad deseada a un aplicador 222 para asegurar que las golosinas 246 en la cadena de montaje 242 sean recubiertas adecuadamente para producir los productos de chocolate deseados 244. Estos parámetros junto con otros parámetros como la temperatura pueden ser utilizados por el controlador 232 para determinar una fuerza y duración del campo eléctrico para obtener una viscosidad predeterminada del chocolate líquido que es beneficiosa para producir productos de chocolate tales como una barra de golosina.

[34] En algunos productos, puede que se desee un chocolate más espeso, mientras que en otros productos, se prefiera un chocolate menos espeso. Por consiguiente, la viscosidad del chocolate líquido se puede controlar dependiendo de los requerimientos de los productos de chocolate.

[35] Sensores (no mostrados) tales como sensores de velocidad de flujo y/o de temperatura se pueden implementar en la tubería para determinar la viscosidad del chocolate líquido en una o más ubicaciones durante el proceso de fabricación. En otro ejemplo, la energía eléctrica que consume la bomba también se puede usar como un indicador de la velocidad de flujo y/o viscosidad del chocolate (es decir, un consumo alto de energía puede indicar una viscosidad alta). El controlador 232 puede utilizar estos datos para controlar a un más el campo eléctrico aplicado a los electrodos 208 y 210. Por ejemplo el chocolate líquido se puede mantener por debajo de un nivel de viscosidad predeterminada para asegurar el funcionamiento adecuado del equipo de facturación.

[36] Se muestra en la figura 2D que el controlador se puede comunicar (es decir, recibir y/o transmitir información) para controlar varias piezas de equipo en el proceso de facturación usando una o varias líneas de control. Estas líneas de control (con alambres o inalámbricas) pueden incluir, sin estar limitadas a, la línea del aplicador de chocolate 234, la línea de la cinta transportadora 236, la línea de interfaz del operador 237, la línea de la bomba 238, la línea del sensor 240 y/o la línea de la válvula 241.

[37] En un ejemplo, el controlador puede controlar el equipo de producción controlando el campo eléctrico aplicado al chocolate líquido, las bombas que bombean el chocolate líquido a través de la tubería, los aplicadores que aplican el chocolate líquido a las golosinas, las cintas transportadoras que mueven las golosinas para que se les aplique el chocolate líquido, los equipos de calentamiento que calientan el chocolate líquido, los sensores para detectar varias características del chocolate líquido

(por ej. la temperatura, la velocidad de flujo, la viscosidad, etc.), las válvulas que permiten que el chocolate líquido fluya a través de las tuberías y aplicadores, las válvulas para mezclar los ingredientes (por ej. la grasa derretida) en el chocolate líquido y unas interfaces del usuario para comunicarse (por ej. entrada y salida de información) a un operador.

[38] La figura 3A es una configuración de pruebas que se utilizó para medir la viscosidad del chocolate líquido en presencia de un campo eléctrico. Como se muestra en la figura 3A, una superficie de calentamiento 306 mantiene el chocolate en forma líquida. El chocolate líquido se fuerza entonces a través de las mallas metálicas 310 y 312 mediante un peso 302 y un pistón 304. A medida que se fuerza el chocolate líquido 308 entre los electrodos 310 y 312, se expone a un campo eléctrico si se aplica un voltaje a los electrodos y se reduce su viscosidad (es decir su velocidad de flujo aumenta si se aplica un campo eléctrico de la fuerza y duración deseadas). El chocolate líquido con viscosidad baja se recoge entonces en un contenedor 314. Entonces, una computadora 318 conectada a una balanza 316 mide la velocidad de flujo.

[39] En un experimento, el chocolate líquido se mantiene alrededor de 40°C utilizando una superficie de calentamiento 306. Por gravedad, el chocolate líquido fluyó a través de las mallas metálicas 310 y 312 que aplicaron un campo eléctrico predeterminado en la dirección de flujo del chocolate. La balanza 316 midió la masa del chocolate líquido como función del tiempo, lo que permitió determinar la velocidad de flujo a través de la tubería.

[40] La figura 4A muestra una gráfica de la velocidad de flujo del chocolate líquido (402, 404, 406, 408 y 410) en función del tiempo para el banco de pruebas de la figura 3A. No se aplicó ningún peso adicional para los datos de la figura 4A. El chocolate líquido fluyó primero en la tubería sin que se aplicase ningún campo eléctrico. La velocidad de flujo fue aproximadamente de 0.0106 g/s (vea 402) lo que indica que la viscosidad del chocolate líquido es alrededor de 41.3 Pa s. Después de que se aplicó un campo eléctrico de 575 V/cm, la velocidad de flujo se aumentó a 0.01798 g/s (vea 404) lo que redujo la viscosidad a 24.46 Pa s (es decir un aumento en la viscosidad del 41% después de la exposición a un campo eléctrico). En este experimento, al chocolate líquido le llevó aproximadamente 1 minuto fluir entre los dos electrodos y en el contenedor 314.

[41] Después de 10 minutos, se desconectó el campo eléctrico y la velocidad de flujo empezó a disminuir indicando que la viscosidad reducida volvió gradualmente a su valor original (es decir vea datos 406, 408 y 410 en los que la velocidad de flujo disminuye gradualmente con el tiempo después de que se ha desconectado el campo eléctrico). En otros experimentos se volvió a aplicar el campo eléctrico al chocolate líquido y se repitió la reducción en la viscosidad.

[42] La figura 3B es otro banco de pruebas similar al banco de pruebas de la figura 3A. Sin embargo, el banco de pruebas de la figura 3B usa gas presurizado (no un peso) para forzar el chocolate líquido a través de la tubería 320. Además, el banco de pruebas de la figura 3B está ubicado dentro de la incubadora 328 para mantener el chocolate a la temperatura deseada. Por lo tanto la superficie de calentamiento 306 no es necesaria en este banco de pruebas.

[43] En general, gas presurizado (por ej. nitrógeno) bajo el control de la computadora 318 se aplica al chocolate líquido 308 a través de la tubería 322. En respuesta a la presión aplicada, el chocolate líquido 308 se fuerza a través de mallas electrificadas 310/312, a través del tubo 320 y en el contenedor 314 donde se mide su peso en la balanza 316. El campo de pruebas en la figura 3B también puede incluir un sensor de temperatura 326 que permite a la computadora monitorizar la temperatura del chocolate líquido durante el proceso de pruebas.

[44] La figura 4B muestra la relación entre el tiempo de aplicación del campo eléctrico y la fuerza óptima del campo eléctrico para el banco de pruebas de la figura 3B. En general, a medida que aumenta el tiempo de aplicación, la fuerza del campo eléctrico disminuye (es decir, cuanto más tiempo tarda en fluir el chocolate a través del campo eléctrico, más baja tiene que ser la fuerza de campo). Esta relación inversa se muestra en las filas 412, 414, 416, 418, 420 y 422 de la tabla en la figura 4B.

[45] La figura 4C muestra una gráfica de la viscosidad del chocolate líquido (424 y 426) en función del tiempo para el banco de pruebas de la figura 3B. En un ejemplo, (correspondiente a la fila 414 de la figura 4B) una muestra de chocolate a 40°C le llevó 9.37 segundos fluir a través de un campo eléctrico de 1838 V/cm. En este ejemplo, la viscosidad se redujo de 43.23 Pa s (vea 424) a 29.53 Pa s (vea 426). Esta particular aplicación del campo eléctrico produjo una reducción del 31.7% en la viscosidad.

[46] Para chocolate temperado, se encontró que el campo eléctrico necesario era ligeramente superior. En general para temperar el chocolate, se ralla el chocolate sólido. Para producir ralladuras finas, se usa una malla para filtrar las partículas. Chocolate sólido con un diámetro inferior a un tamaño fijo (por ej. 150 micrómetros) se usa como semilla. Se funde alrededor de 1 kg de chocolate a 40°C y se enfría a 30°C. Después de que se mezclaron 10 g de chocolate sólido fino, se empezó el experimento usando el banco de prueba. Se hace notar que la viscosidad del chocolate temperado aumenta muy rápidamente. Solidifica en aproximadamente 30 minutos. Dentro de este período de tiempo, sin embargo, se puede aplicar un campo eléctrico para reducir su viscosidad.

[47] Las figuras 4D y 4E muestran gráficas de la velocidad de flujo (428, 430, 432, 434, 436, 438 y 440) y viscosidad (442, 444, 446, 448, 450, 452 y 454) en relación al tiempo respectivamente para el chocolate temperado. Como se muestra en la figura 4D, nueve minutos después de la mezcla, la velocidad de flujo era 0.477545 g/s (vea 428) bajo 1.56 Psi de presión. Cuando se conectó el campo eléctrico, la velocidad de flujo aumentó de 0.584745 g/s (vea 430) (un aumento del 22.45%). Después de 100 segundos de la aplicación del campo eléctrico, se desconectó el campo eléctrico y la velocidad de flujo correspondiente era de 0.465407 g/s (vea 432). La velocidad de flujo se midió cada 30 segundos desde ese momento. En aproximadamente 180 segundos, la velocidad de flujo disminuyó de 0.33801 g/s (vea 440) (una reducción del 27.3%). Esto indicó que el chocolate temperado se estaba solidificando.

[48] De la velocidad de flujo, se dedujo que la viscosidad (vea figura 4E) era aproximadamente 121.82 Pa s (vea 442) nueve minutos después de la mezcla. Cuando se aplicó un campo eléctrico de

1.2 kV/cm, la viscosidad bajó a 99.487 Pa s (vea 444). Después de que se desconectó el campo eléctrico, la viscosidad era de 125.0 Pa s (vea 446). En otros tres minutos, la viscosidad aumentó a 172.1 Pa s (vea 454).

[49] Se hace notar que los inventores han descubierto que un rango adecuado para el campo eléctrico es entre 100 V/cm y 6000 V/cm y funciona particularmente bien en el rango de 500 V/cm a 800 V/cm para algunas clases de chocolate (por ej. chocolate con leche que se puede obtener en Hershey, Hershey Pensilvania). Si el campo eléctrico aplicado es demasiado débil, puede que no se note la reducción en la viscosidad. Por otra parte, si el campo eléctrico aplicado es demasiado fuerte, la viscosidad puede, de hecho, aumentar. Porque el chocolate líquido tiene un gran efecto electrorreológico (ER) los agregados de estructura sólida pueden hacerse demasiado grandes si se exponen a un campo eléctrico demasiado fuerte, lo que podría llevar a un aumento en la viscosidad (por ej. si los agregados aumentan de tamaño de micrómetro a un tamaño macroscópico mayor).

[50] Como se ha descrito más arriba, la duración del campo eléctrico se puede elegir en base a la fuerza del campo eléctrico seleccionada (por ej. si el campo es más fuerte, entonces la duración se puede acortar) o viceversa. También se hace notar que la duración del campo eléctrico aplicada al chocolate líquido es igual al tiempo que le lleva al chocolate líquido pasar a través del campo eléctrico. La duración de este tiempo se puede cambiar si fuera necesario ajustando la velocidad de flujo del chocolate líquido (por ej. aumentando/disminuyendo la energía de la bomba) y/o aumentando/disminuyendo la separación entre los dos electrodos. Seleccionando una combinación de la fuerza del campo eléctrico y la duración de ese campo, se puede optimizar la reducción en la viscosidad para el flujo del chocolate líquido en la tubería. Además se hace notar que se vio que la corriente eléctrica que fluye entre las mallas en los bancos de pruebas era muy pequeña (por ej. un par de micro amperios). Esto indica que el sistema es eficiente energéticamente al mismo tiempo que reduce la viscosidad del chocolate.

[51] Aunque el invento se ilustra y describe en la presente con referencia a encarnaciones específicas, no es la intención que el invento esté limitado por los detalles mostrados. Sino que se pueden hacer varias modificaciones en los detalles dentro del alcance y rango de equivalencia de las reclamaciones y sin apartarse del invento.

RECLAMACIONES

1. Un método para producir un producto de chocolate, el método incluye:
suministrar chocolate líquido con cierta viscosidad a través de una tubería a lo largo de una vía de suministro a una estación de producción para producir un producto de chocolate, el chocolate líquido incluye partículas sólidas suspendidas en el chocolate líquido; y
cambiar la viscosidad del chocolate líquido mediante la aplicación de un campo eléctrico al chocolate líquido en una dirección a lo largo de la vía de suministro de una fuerza y duración determinada para agregar las partículas sólidas suspendidas en formas aerodinámicas que se extienden en la dirección de la vía de suministro.
2. El método de la reclamación 1, en el que cambiar la viscosidad comprende:
aplicar el campo eléctrico en un rango de fuerza entre 300 V/cm y 1000 V/cm.
3. El método de la reclamación 1,
en el que el chocolate líquido comprende grasa derretida y partículas sólidas suspendidas en la grasa derretida, y
en el que las partículas sólidas suspendidas incluyen al menos una de partículas de azúcar, partículas de cacao o partículas de leche.
4. El método de la reclamación 1, que comprende además:
el determinar la fuerza y duración para la aplicación del campo eléctrico al chocolate líquido basado en una consistencia predeterminada del producto de chocolate.
5. El método de la reclamación 1, que comprende además:
el determinar la fuerza y duración para la aplicación del campo eléctrico al chocolate líquido basado en un contenido en grasa predeterminado del producto de chocolate.
6. El método de la reclamación 1, que comprende además:
determinar la fuerza y duración para la aplicación del campo eléctrico al chocolate líquido basado en un tipo de chocolate usado en la producción del producto de chocolate.
7. El método de la reclamación 1,
controlando la fuerza y duración para la aplicación el campo eléctrico basándose en la velocidad de flujo del chocolate líquido determinada a lo largo de la vía de suministro.
8. El método de la reclamación 1,
controlando la fuerza y duración para la aplicación del campo eléctrico basándose en la viscosidad del chocolate líquido determinada a lo largo de la vía de suministro.
9. El método de la reclamación 1,
temperando el chocolate líquido antes de la suministración del chocolate líquido a través de la tubería.

10. Un sistema para producir un producto de chocolate, el sistema comprende:
una tubería de suministro de chocolate para que fluya el chocolate líquido con una cierta viscosidad a lo largo de la vía de suministro a una estación que produce el producto de chocolate, el chocolate líquido incluye partículas líquidas suspendidas en el chocolate líquido; y
al menos dos electrodos integrados dentro de la tubería de suministro de chocolate para cambiar la viscosidad del chocolate líquido mediante la aplicación de un campo eléctrico al chocolate líquido en una dirección a lo largo de la vía de suministro de una fuerza y duración determinada para agregar las partículas sólidas en formas aerodinámicas que se extienden en la dirección de la vía de suministro.
11. El sistema de la reclamación 10,
en el que los al menos dos electrodos son mallas metálicas acopladas a un par de respectivos terminales de salida de una fuente de energía eléctrica que produce un campo eléctrico.
12. El sistema de la reclamación 10,
en el que los al menos dos electrodos son anillos metálicos acoplados a un par de respectivos terminales de salida de una fuente de energía eléctrica que produce un campo eléctrico.
13. El sistema de la reclamación 10, comprendiendo además
un controlador acoplado a los al menos dos electrodos para controlar la fuerza y duración del campo eléctrico aplicado al chocolate líquido para reducir la viscosidad a un nivel predeterminado.
14. El sistema de la reclamación 10, comprendiendo además
un controlador, y
en donde el controlador controla una velocidad de fluido del chocolate líquido para ajustar la duración del tiempo durante el cual se aplica el campo eléctrico al chocolate líquido.
15. El sistema de la reclamación 10, donde
los electrodos están espaciados para producir una separación entre los electrodos, y la separación se ajusta para controlar el tiempo durante el cual se aplica el campo eléctrico al chocolate líquido.
16. El sistema de la reclamación 10, comprendiendo además
una fuente de grasa derretida; y
un controlador controlando una cantidad de grasa derretida incluida en el chocolate líquido basada en el campo eléctrico.
17. El sistema de la reclamación 10, comprendiendo además
un sensor localizado en la tubería de suministro del chocolate para medir la velocidad de flujo o viscosidad del chocolate líquido.
18. El sistema de la reclamación 17, comprendiendo además
una bomba para bombear el chocolate líquido a través de la tubería de suministro del chocolate, la velocidad de la bomba se controla basándose en una señal recibida del sensor localizado en la tubería de suministro del chocolate.

19. Un sistema para producir un producto de golosina bañado en chocolate, el método comprendiendo:

una tubería de suministro de chocolate y una bomba para hacer fluir el chocolate líquido con cierta viscosidad a lo largo de la vía de suministro a un aplicador, el chocolate líquido incluyendo partículas sólidas suspendidas en el chocolate líquido, el aplicador aplicando el chocolate líquido a un producto de golosina para producir el producto de golosina bañado en chocolate;

al menos dos electrodos integrados dentro de la tubería de suministro del chocolate para cambiar la viscosidad del chocolate líquido mediante la aplicación de un campo eléctrico al chocolate líquido en una dirección a lo largo de la vía de suministro a una aplicador de una fuerza y duración para agregar las partículas sólidas suspendidas en formas aerodinámicas que se extienden a lo largo de la dirección de la vía de suministro; y

un controlador para controlar la fuerza del campo eléctrico, la duración del campo eléctrico y una velocidad de bombeo de la bomba para suministrar chocolate líquido a una viscosidad predeterminada al aplicador.

20. El sistema de la reclamación 19, comprendiendo además

al menos otros dos electrodos integrados dentro de la tubería de suministro del chocolate para cambiar la viscosidad del chocolate líquido mediante la aplicación de otro campo eléctrico al chocolate líquido en una dirección a lo largo de la vía de suministro al aplicador.

21. El sistema de la reclamación 19, comprendiendo además

sensores integrados dentro de la tubería de suministro del chocolate para percibir la velocidad de flujo o la viscosidad del chocolate líquido.

22. El sistema de la reclamación 19, donde

el controlador determina una velocidad de flujo o una viscosidad del chocolate líquido basándose en el consumo de energía eléctrica de la bomba.

23. El sistema de la reclamación 19, donde

el chocolate líquido se bombea desde un tanque de chocolate líquido y el controlador controla la mezcla del chocolate líquido en el tanque basándose en la viscosidad predeterminada.

24. El sistema de la reclamación 19, donde

el controlador incluye una interfaz de operador que tiene una entrada y un monitor para un operador del sistema para controlar manualmente la velocidad de flujo o viscosidad del chocolate líquido.

25. El sistema de la reclamación 19, donde

los al menos dos electrodos son electrodos metálicos recubiertos con plástico de grado alimenticio no conductor.

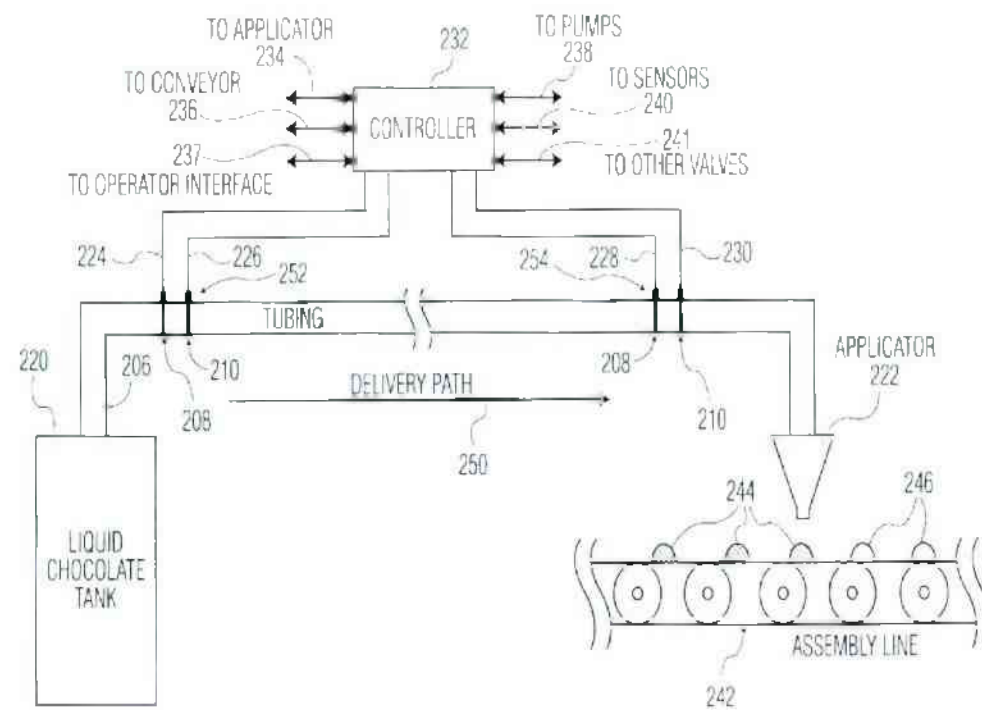


FIG. 2D

1/9



FIG. 1

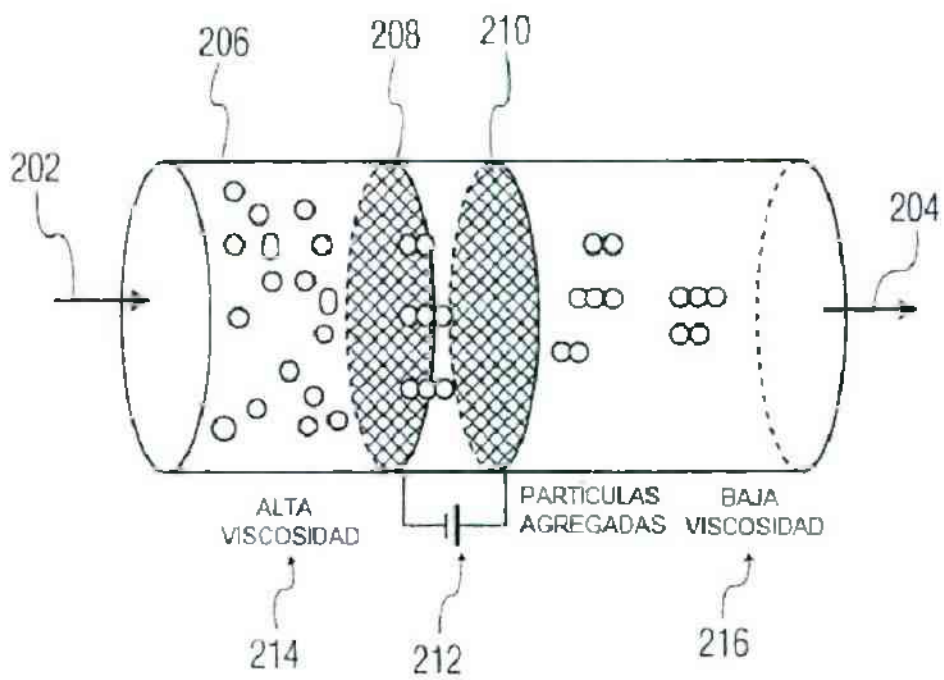


FIG. 2A

2/9

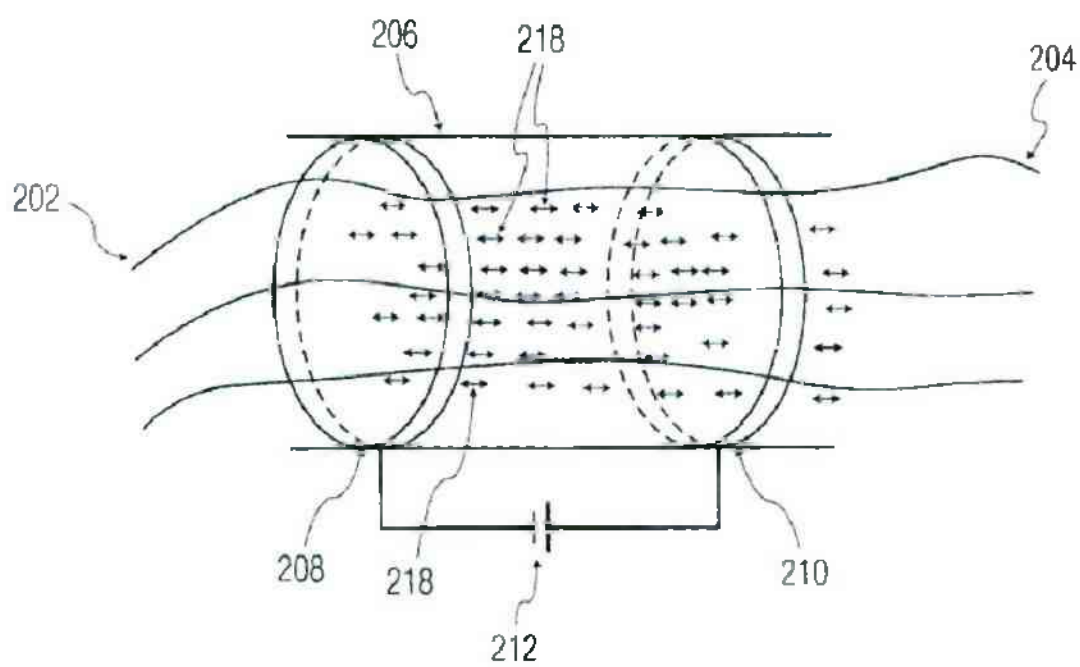


FIG. 2B

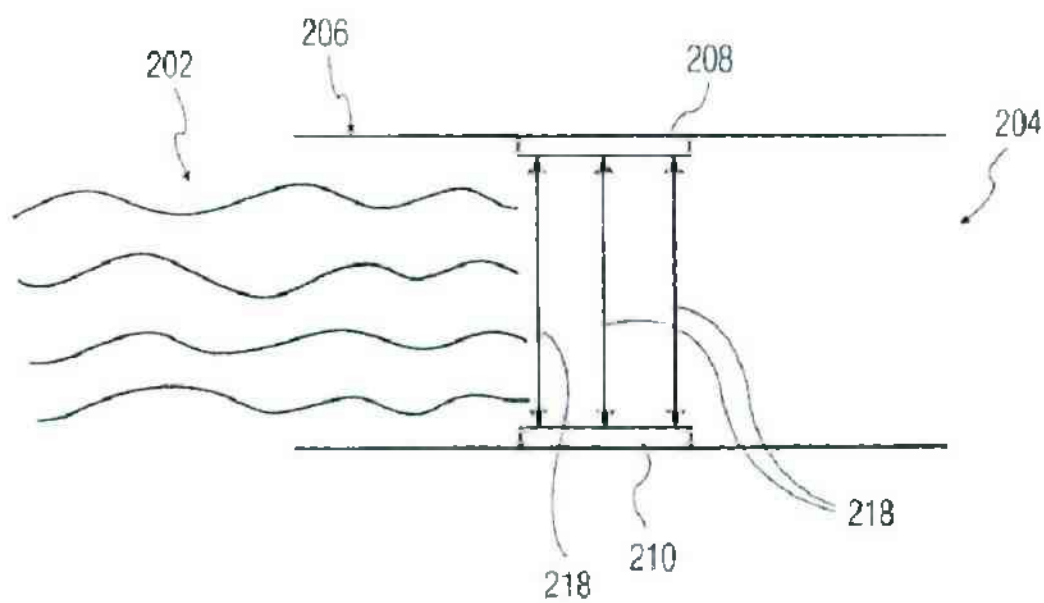


FIG. 2C

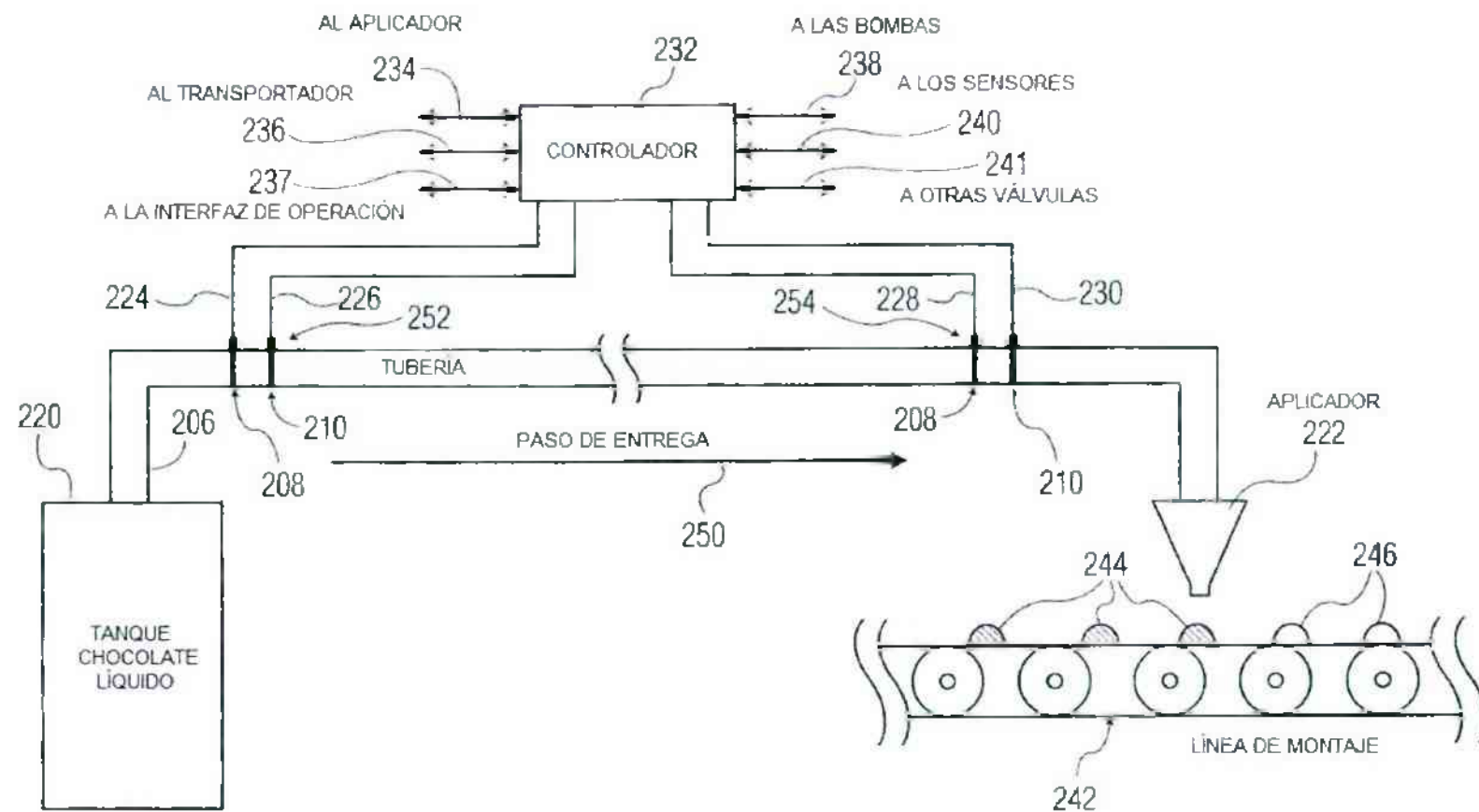


FIG. 2D

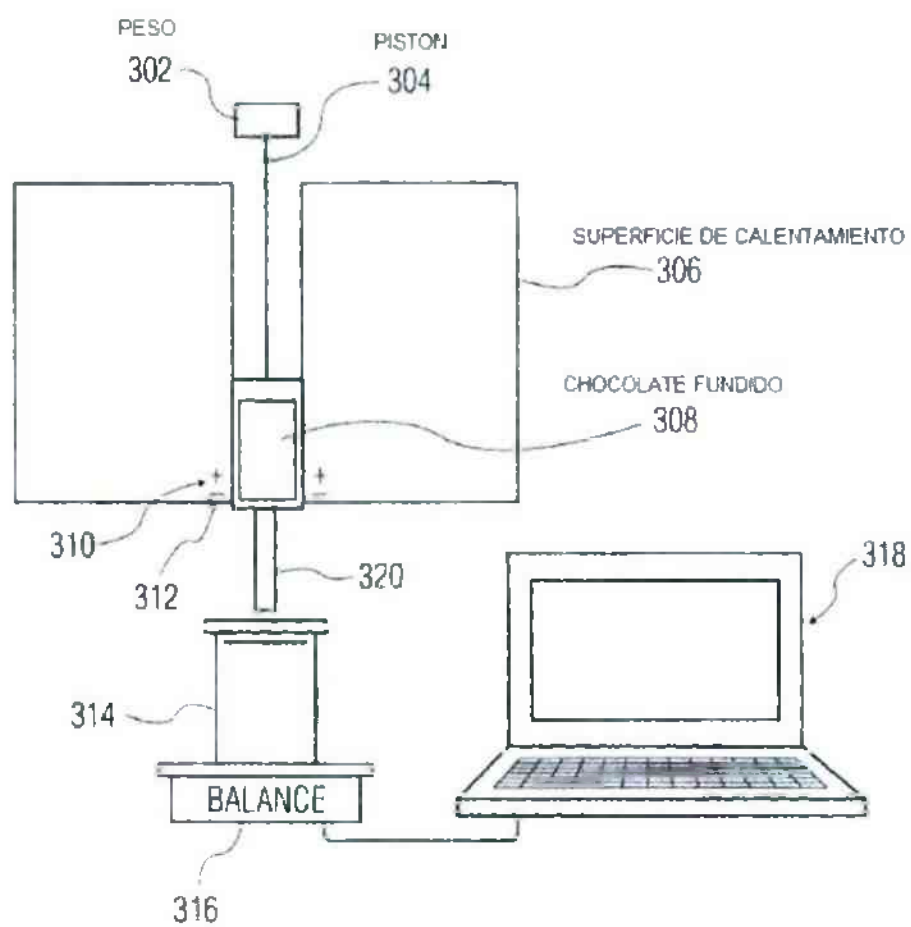


FIG. 3A

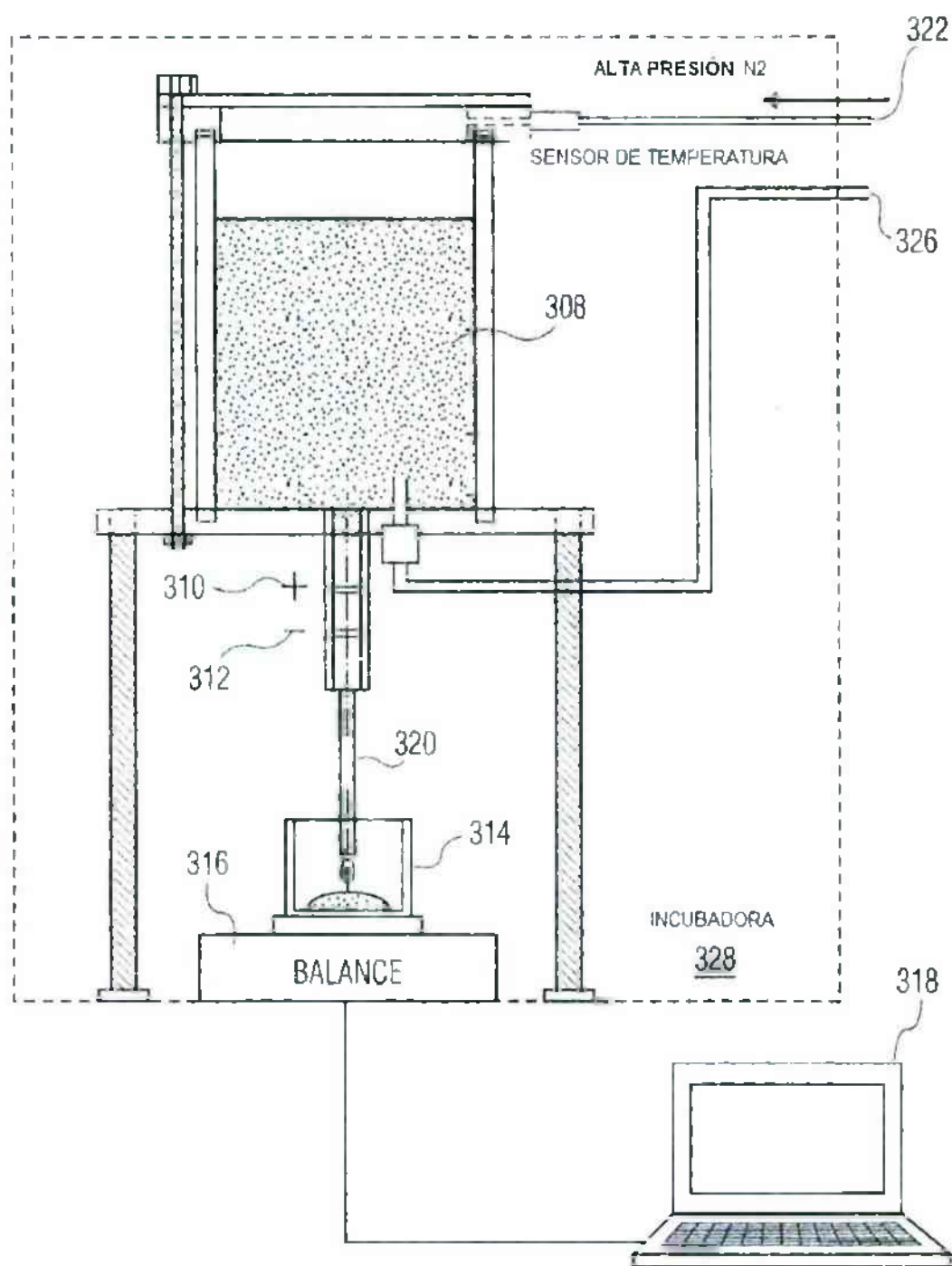


FIG. 3B

HOJA
ENBLANCO

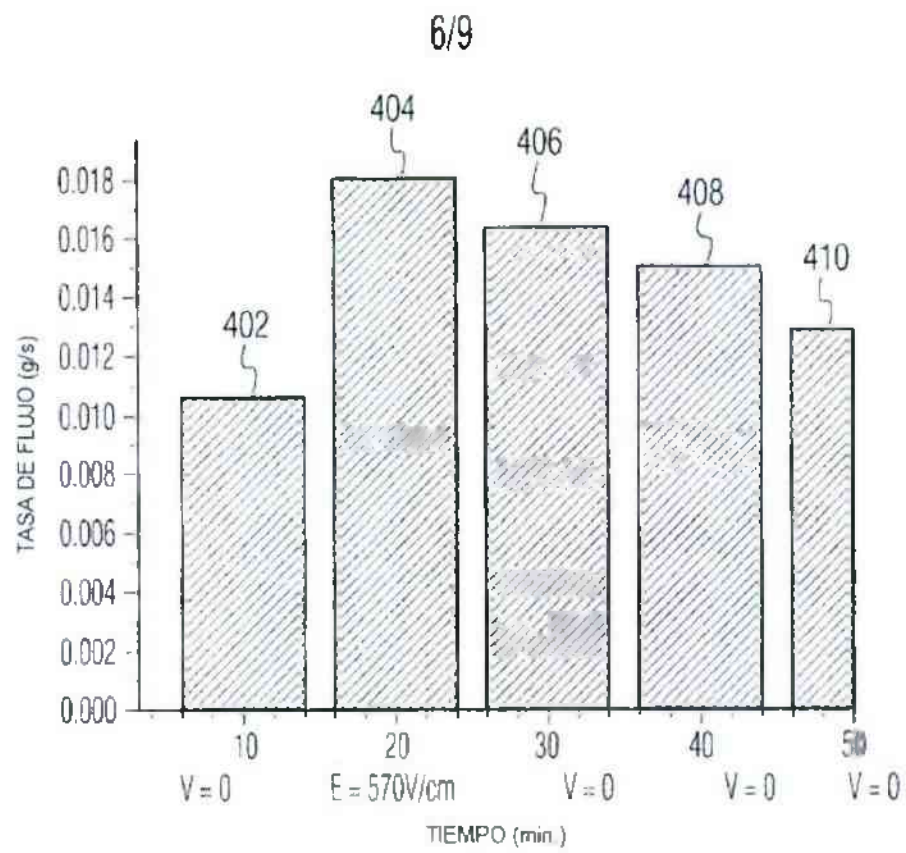


FIG. 4A

	TIEMPO PARA QUE EL FLUJO DE CHOCOLATE PASE EL CAMPO ELÉCTRICO (S)	CAMPO ELÉCTRICO ÓPTIMO (V/cm)
412	5.0	2517
414	9.37	1838
416	13.7	1520
418	19.0	1291
420	24.2	1144
422	39.3	898

FIG. 4B

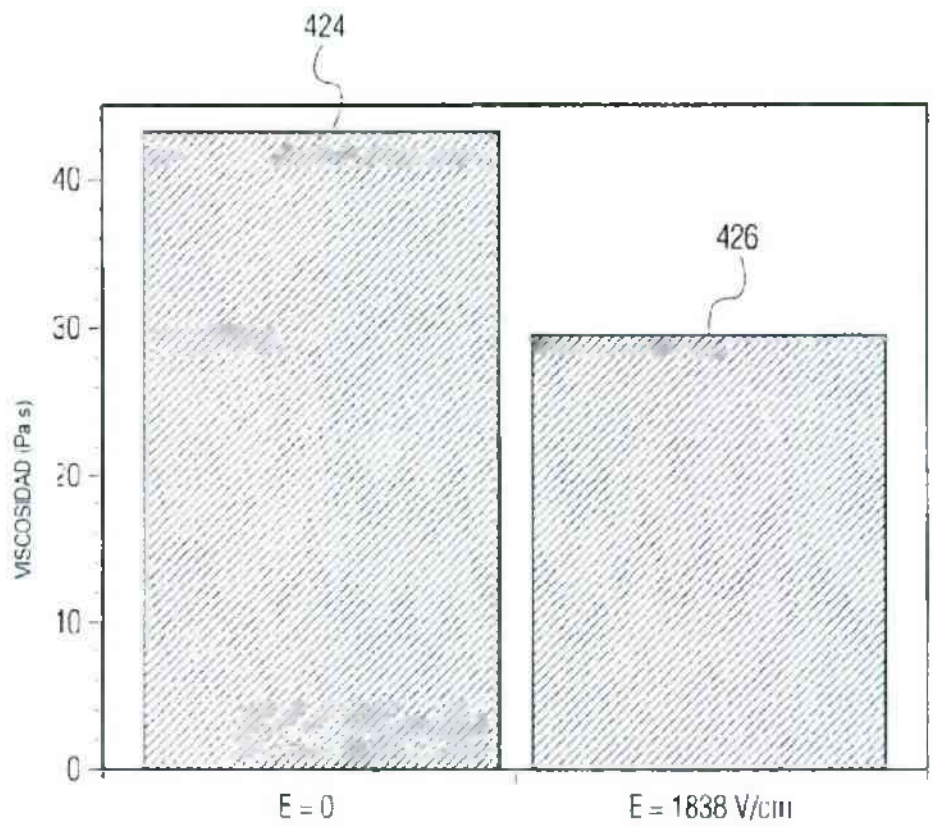


FIG. 4C

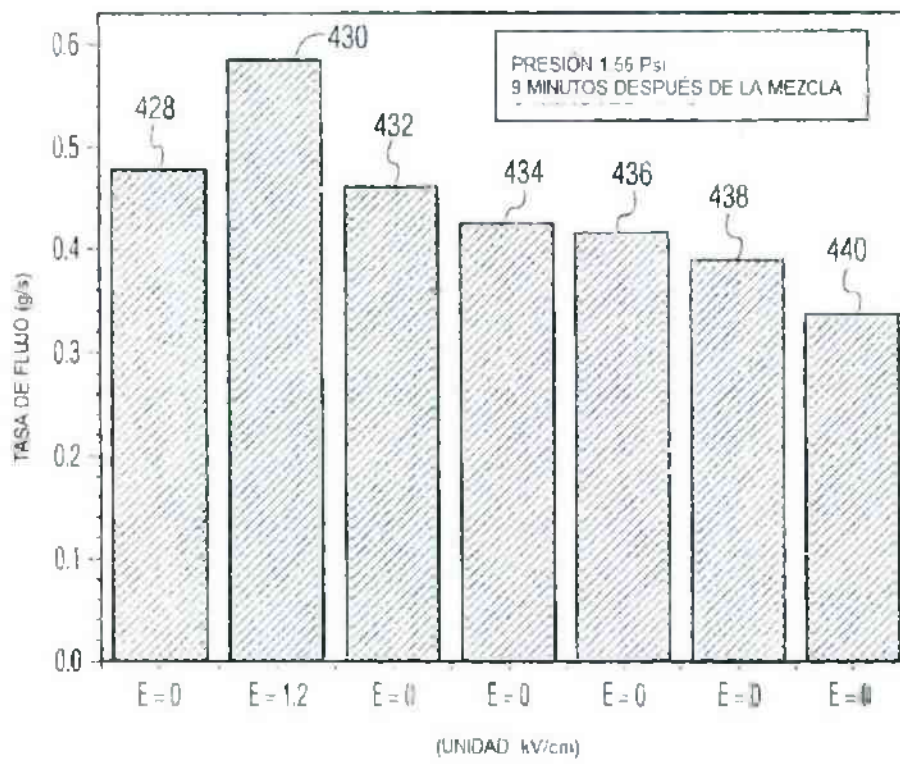


FIG. 4D

AOL
ERBLANCO

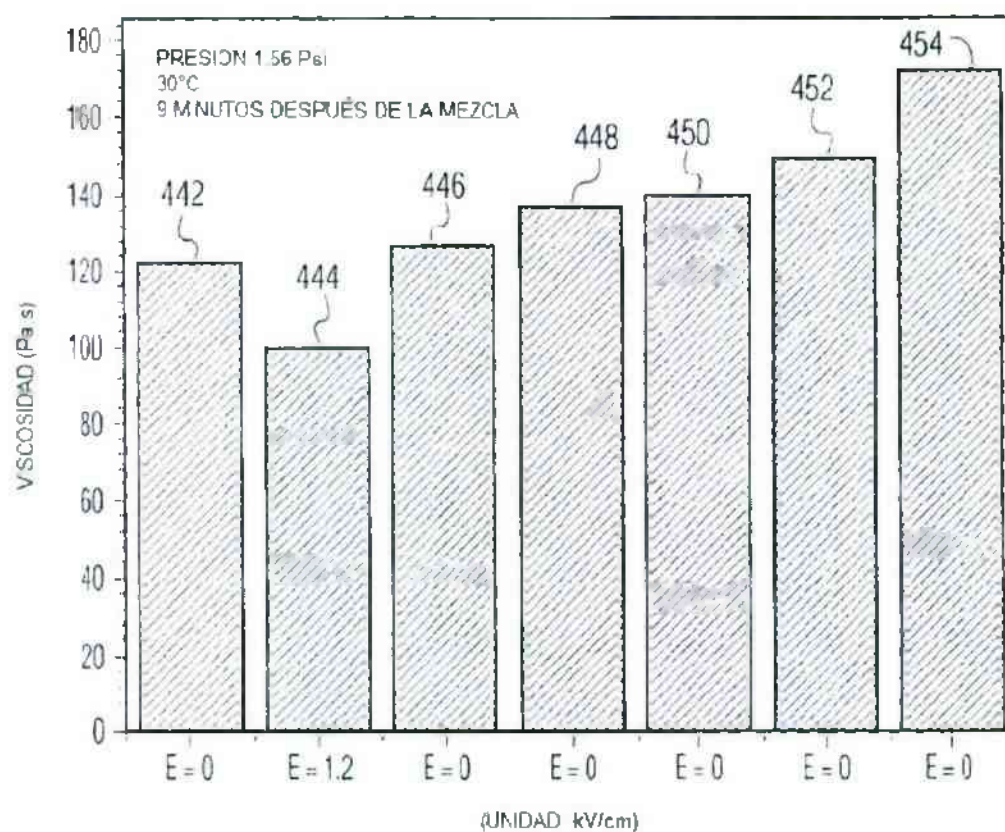


FIG. 4E

CESIÓN – Solicitud de PatenteNúmero de expediente: **TUN-603USP**

Considerando que, el cedente, que comprende a los siguientes inventores:

CEDENTE(s)/
INVENTOR(s)1. **Rongjia Tao**2. **Hong Tang**

3.

4.

5.

6.

Creó una invención titulada: **MÉTODO DE PRODUCCIÓN DE CHOCOLATE Y APARATOS**

Para la cual una solicitud de patentes de invención de los Estados

Unidos: (Seleccione una de las siguientes):

- ☐ se ejecuta simultáneamente con la presente
- ☐ fue presentada ante la oficina de Patentes y marcas de los Estados Unidos el día _____, como una solicitud de patente de los Estados Unidos con No. de Serie: _____

CESIONARIO (Nombre
completo y dirección)

TEMPLE UNIVERSITY – del Sistema de educación superior de la Commonwealth

Broad Street and Montgomery Avenue Philadelphia, PA 19122-6099

Está interesado en adquirir todo el interés de y para la invención mencionada y las patentes de invención para ser obtenidas que se obtengan de la misma.

Ahora, por ende, en consideración al pago realizado por el cesionario al cedente de una suma correspondiente a un dólar (\$1.00), y por otra consideración buena y valiosa, el recibo de las cuales se reconocen por este medio, el Cedente, con la intención de obligarse legalmente, por la presente vende, cede y transfiere al cesionario, sus sucesores y cesionarios, plena y exclusivamente los derechos, títulos e intereses sobre y para dicha invención, todas las solicitudes de patentes de invención de dicha invención, incluyendo todas las divisiones, continuaciones y continuaciones en parte de la misma, todo derecho a reclamar prioridad basado en la misma, y todas las Patentes de invención, incluyendo reediciones, que se obtengan de la misma, incluyendo cualquiera y todos los derechos de patente extranjera de esta invención que correspondan a la misma.

El cedente garantiza por este medio que ninguna cesión, venta, acuerdo o gravamen ha sido o será realizado o celebrado que entrara en conflicto con esta asignación.

El cedente acepta que quedará legalmente obligado, a petición del cesionario o sus sucesores o cesionarios o un representante legal de la misma, a facilitar toda la información y pruebas de las que el cedente tenga conocimiento o posesión, en relación con la elaboración y la práctica de dicha invención, al testificar en cualquier procedimiento legal relativo a la misma, para ejecutar todos los instrumentos apropiados para patentar la invención en los Estados Unidos de América y los países extranjeros en el nombre del cesionario, y ejecutar todos los instrumentos adecuados para llevar a cabo la intención de este instrumento.

Si la invención requiere un depósito biológico, el Cedente otorga también al cesionario tal control sobre cualquier depósito hecho por el Cedente que sea necesario para la validez de los derechos de patentes asignadas en el presente documento.

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CESIÓN – Solicitud de Patente

Número de expediente:
TUN-603USP

El Cedente autoriza al abogado del Cesionario a insertar al final de este documento el número de serie y la fecha de presentación de la solicitud mencionada para las Patentes de invención de los Estados Unidos y/o el número de expediente de abogado o archivo designado para esta solicitud si no ha sido identificado arriba.

Si el Cedente incluye a más de un individuo, estas obligaciones aplicarán para estas personas, tanto individual como colectivamente.

En fe de lo cual, esta asignación se ejecuta en el día indicado a continuación.

FIRMA

Nombre impreso	Firma	Fecha
1. Rongjia Tao	(Ilegible)	20 de enero de 2012
	(Ilegible)	20 de enero de 2012
	Testigo del cedente No. 1	
2. Hong Tang	(Ilegible)	20 de enero de 2012
	(Ilegible)	20 de enero de 2012
	Testigo del cedente No. 2	
3.		
	Testigo del cedente No. 3	
4.		
	Testigo del cedente No. 4	
5.		
	Testigo del cedente No. 5	
6.		
	Testigo del cedente No. 6	

Solicitud para patentes de invención Los Estados Unidos

de

Serial No.:

Presentado:

Número de expediente de abogado: TUN-603USP

Número total de páginas de la cesión

2

* Se recomienda anexar firma del testigo, obligatoria para algunos países

ASSIGNMENT - Patent ApplicationDocket Number: **TUN-603USP**

Whereas, the Assignor, comprising the following named inventors:

ASSIGNOR(s)/ INVENTOR(s)	1. Rongjia Tao	2. Hong Tang
	3.	4.
	5.	6.

made an invention entitled: **CHOCOLATE PRODUCTION METHOD AND APPARATUS**

for which an application for Letters Patent of the United States:

(Select one of the following):

- ☐ is executed concurrently herewith
☐ was filed in the U.S. Patent and Trademark Office on _____
as U.S. Patent Application Serial No.: _____

ASSIGNEE
(Full Name and Address)

TEMPLE UNIVERSITY - of the Commonwealth System of Higher Education
Broad Street and Montgomery Avenue
Philadelphia, PA 19122-6099

Is desirous of acquiring the entire interest in and to said invention and the Letters Patent to be obtained therefor,

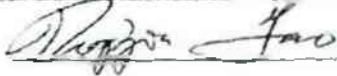
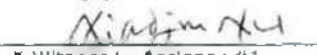
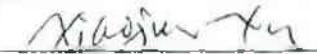
Now, therefore, in consideration of the payment by Assignee to Assignor of a sum corresponding to One Dollar (\$1.00), and for other good and valuable consideration, the receipt of which is hereby acknowledged, Assignor, intending to be legally bound, hereby sells, assigns and transfers to Assignee, its successors and assigns, the full and exclusive right, title and interest in and to said invention, all applications for Letters Patent for said invention, including all divisions, continuations, and continuations-in-part thereof, all rights to claim priority based thereon, and all Letters Patent, including reissues, to be obtained therefor, including any and all foreign patent rights in this invention corresponding thereto.

Assignor hereby warrants that no assignment, sale, agreement or encumbrance has been or will be made or entered into which would conflict with this Assignment.

Assignor agrees it shall be legally bound, upon request of the Assignee or its successors or assigns or a legal representative thereof, to supply all information and evidence of which the Assignor has knowledge or possession, relating to the making and practice of said invention, to testify in any legal proceeding relating thereto, to execute all instruments proper to patent the invention in the United States of America and foreign countries in the name of the Assignee, and to execute all instruments proper to carry out the intent of this instrument.

If the invention requires a biological deposit, Assignor also grants to Assignee such control over any deposit made by Assignor as may be necessary to the validity of the patent rights assigned herein.

ASSIGNMENT - Patent Application	Docket Number: TUN-603USP
Assignor authorizes Assignor's attorney to insert at the end hereof, the serial number and filing date of the aforesaid application for United States Letters Patent and/or the Attorney Docket or file designation for this application if not identified above.	
If the Assignor includes more than one individual, these obligations shall apply to these individuals both individually and collectively.	
In witness whereof, this Assignment is executed on the day indicated below.	

Typed or Printed Name	Signature	Date
1. Rongjia Tao		Jan. 20, 2012
	 * Witness to Assignor #1	Jan. 20, 2012
2. Hong Tang		1-20-12
	 * Witness to Assignor #2	Jan. 20, 2012
3.		
	* Witness to Assignor #3	
4.		
	* Witness to Assignor #4	
5.		
	* Witness to Assignor #5	
6.		
	* Witness to Assignor #6	

Application for United States Letters Patent:	
Serial No.:	
Filed:	
Attorney Docket Number:	TUN-603USP
Total Number of Assignment Pages	2 * Witness signature recommended, mandatory for some countries

CHOCOLATE PRODUCTION METHOD AND APPARATUS
CROSS REFERENCE TO RELATED APPLICATIONS

[1] This application claims priority to U.S. Provisional Application No.61/592,648, filed January 31, 2012. The contents of U.S. Provisional Application No.61/592,648 are
5 incorporated by reference herein.

FIELD

[2] The present invention relates to chocolate production methods and apparatus.

SUMMARY

[3] The present invention relates to a method and an apparatus for producing a
10 chocolate product. The method includes delivering liquid chocolate having a viscosity through a pipe along a delivery path to a production station for producing the chocolate product. The liquid chocolate includes solid particles suspended within the liquid chocolate. The method changes the viscosity of the liquid chocolate by applying an electric field to the liquid chocolate in a direction along the delivery path to aggregate
15 the suspended solid particles into streamline shapes arranged in short chains extending along the direction of the delivery path.

BACKGROUND

[4] Chocolate contains antioxidants and therefore may provide health benefits. Conventional chocolate products contain excess fat which may lead to health concerns
20 such as obesity. In fact, most chocolate products contain 25% to 35% fat content.

[5] In general, liquid chocolate used to manufacture chocolate products includes excess melted fat (e.g. cocoa butter) that is purposely added to the liquid chocolate in an attempt to lower the viscosity for manufacturing purposes. This excess melted fat is used because even at the chocolate melting temperature, the viscosity of liquid
25 chocolate may be too high for manufacturing. Thus, an unhealthy amount of fat may be added to the liquid chocolate for the purposes of reducing the viscosity during manufacturing.

BRIEF DESCRIPTION OF THE FIGURES

[6] Figure 1 is a graph depicting the relationship between shear stress and shear
30 rate for liquid chocolate according to an embodiment of the present invention.

[7] Figure 2A is a side view of an electric field being applied to the liquid chocolate as it flows through a pipe according to an embodiment of the present invention.

[8] Figure 2B is a side view of an electric field being applied to the liquid chocolate as it flows through a pipe according to another embodiment of the present invention.

[9] Figure 2C is a side view of solid columns formed perpendicular to the flow of the
35 liquid chocolate within the pipe according to an embodiment of the present invention.

[10] Figure 2D is a side view of chocolate product manufacturing equipment applying an electric field to the liquid chocolate according to an embodiment of the present invention.

[11] Figure 3A is a system diagram of a test bench utilized to measure the flow rate of the liquid chocolate as an electric field is applied according to an embodiment of the present invention.

[12] Figure 3B is a system diagram of another test bench utilized to measure the flow rate of the liquid chocolate as an electric field is applied according to an embodiment of the present invention.

[13] Figure 4A is a graph depicting the flow rate versus time as an electric field is applied to the liquid chocolate in the test bench of Figure 3A according to an embodiment of the present invention.

[14] Figure 4B is a table depicting the electric field application time versus strength as an electric field is applied to the liquid chocolate in the test bench of Figure 3B according to an embodiment of the present invention.

[15] Figure 4C is a graph depicting the viscosity versus time as an electric field is applied to the liquid chocolate in the test bench of Figure 3B according to an embodiment of the present invention.

[16] Figure 4D is a graph depicting the flow rate versus time as an electric field is applied to the liquid chocolate in the test bench of Figure 3B according to an embodiment of the present invention.

[17] Figure 4E is a graph depicting the viscosity versus time as an electric field is applied to the liquid chocolate in the test bench of Figure 3B according to an embodiment of the present invention.

DETAILED DESCRIPTION

[18] The present invention provides methods and systems for reducing the viscosity of liquid chocolate as it is flowing (e.g. through a metal or plastic pipe) or coating a product during production of a chocolate product. Specifically, an electric field is applied along the direction of the flow of the liquid chocolate (e.g. along a direction of a delivery path through the pipe delivering liquid chocolate to a production station that produces chocolate products) at a specified strength and duration in order to aggregate solid particles suspended within the liquid chocolate. As the particles aggregate into streamlined shapes along the flow direction, the viscosity of the liquid chocolate decreases. The size of the streamlined aggregates is controlled by the combination of electric field strength and duration. Embodiments of the methods and systems described herein allow for control of liquid chocolate viscosity without the need to add excess melted fat.

[19] Liquid chocolate is a suspension comprised of solid particles (e.g. sugar particles, cocoa particles, milk particles, etc.) suspended in a liquid that is typically melted fat (e.g. cocoa butter or an equivalent). In general, liquid cocoa butter behaves as a Newtonian fluid. However, with the addition of the suspended particles, the liquid chocolate deviates from Newtonian behavior. In general, the shear stress of the liquid chocolate has pseudo plastic behavior. As shown in Figure 1, the relationship between the shear stress and the shear rate is close to exponential (i.e. it is not linear), and can be modeled by the Casson Model shown in equation 1 below.

$$\sigma^{0.5} = \sigma_0^{0.5} + K_1 (\dot{\gamma})^{0.5} \quad (\text{Equation 1})$$

where σ is the shear stress, σ_0 is the yield shear stress, $\dot{\gamma}$ is the shear rate and K_1 is a constant. From the Casson model it is found that the viscosity η of liquid chocolate (described in equation 2) decreases as the shear rate increases.

$$\eta = \frac{\sigma}{\dot{\gamma}} \quad (\text{Equation 2})$$

[20] Two characteristics of liquid chocolate is yield shear stress and its viscosity. The value of the yield shear stress is related to the minimum energy required to start the chocolate flowing. If the yield shear stress is high, the chocolate will be thicker and tend to stand up, which may be beneficial for putting on sweets or in producing chocolate morsels for baked cookies, for example. A low yield shear stress may be beneficial to give a thin coating of chocolate over a biscuit, for example.

[21] In general, viscosity is a measure of resistance of a fluid which is being deformed by either shear or tensile stress. Viscosity determines the size of the pumps needed to pump the liquid chocolate through pipes and determines a coating thickness on a potential chocolate product. If a strong electric field is applied to liquid chocolate in a direction perpendicular to the shear or flow direction (see Figure 2C), then the yield stress and viscosity are increased. As chocolate flows from section 202 in pipe 206 towards section 204, the electrical field applied by electrodes 208 and 210 (e.g. acting as a capacitor) induce the solid particles in the liquid chocolate to align with each other and form solid vertical columns 218 perpendicular to the flow by a dipolar interaction. This effect (i.e. the Winslow effect) increases the viscosity of the liquid chocolate exposed to the electric field and may completely stop the flow of chocolate through pipe 206 (i.e. vertical columns 218 perpendicular to the flow would block the flow from exiting the pipe at 204).

[22] By arranging the electrodes in a manner shown in Figures 2A and 2B, however, an electric field is generated between the electrodes in a direction parallel or anti-parallel (i.e. along the delivery path) to the flow of the chocolate through pipe 206.

The delivery path may be flowing from a vessel which holds the liquid chocolate, through the pipe, to a production station that produces chocolate products at a desired viscosity.

[23] Electrodes 208 and 210 are positioned within pipe 206. In one embodiment (Figure 2A), electrodes 208 and 210 may be metallic meshes (e.g. a pair of grates) that allows the chocolate to flow through the electrodes along the delivery direction of the pipe. In another embodiment (Figure 2B), electrodes 208 and 210 may be metallic rings, which are formed or mounted on the pipe's inner wall. Electrodes 208 and 210 may be electrically connected to an electrical power supply 212 that includes a power source and an electronic controller 232 for applying a voltage potential across electrodes 208 and 210, which results in an electric field between the electrodes. Electrodes 208 and 210 may also be coated with a non-conductive material (e.g. food grade plastic and/or rubber) to prevent the liquid chocolate from coming in direct contact with the electrodes. This coating may be useful in reducing electrical current flowing between the electrodes, and ensuring the integrity of the metallic electrodes over prolonged use.

[24] In general, as the liquid chocolate flows through pipe 206, it has a relatively high viscosity in region 202, including 214. As it flows between electrodes 208 and 210, the solid particles suspended in the liquid chocolate begin to agglomerate into larger stream line aggregates resulting in a reduced viscosity in region 216 and 204.

[25] Specifically, as shown in Figure 2A and Figure 2B, as the liquid chocolate flows from the left to the right along pipe 206, the liquid chocolate passes through the electric field between electrodes 208 and 210. The solid particles suspended in the liquid phase are polarized by the electric field. The induced dipolar interaction forces the particles to temporarily aggregate into short chains or ellipsoids that are along the flow direction. The size of the streamlined shapes may be relatively small (e.g. less than or equal to one hundred micro-meters).

[26] In general, the aggregated chains in Figures 2A and 2B are different from the aggregated chains in Figure 2C, because the aggregated chains in Figures 2A and 2B are small and are arranged along the flow direction of the liquid chocolate. The flow of these streamlined particle aggregates becomes organized in short chains along the pipe direction, so that the apparent viscosity of the liquid chocolate is reduced.

[27] Thus, the relatively high viscosity liquid chocolate on the left side of the pipe in Figure 2A and Figure 2B is agglomerated between electrodes 208 and 210 which produce a liquid chocolate on the right side of pipe 206 having reduced viscosity. The reduced viscosity may gradually increase back to the original viscosity value over a period of time after being exposed to the electrical field.

[28] In operation, liquid chocolate passes through electrodes 208 and 210 positioned in at least one of a plurality of locations within a delivery pipe (e.g. a metal or plastic vessel) during the manufacture of chocolate products (e.g. candy bars, etc.). An example of chocolate product manufacturing equipment is shown in Fig. 2D where

5 liquid chocolate is pumped from tank 220, through pipe 206 (along delivery path 250) and is applied to candy 246, for example, using applicator 222 to produce a chocolate product 244 (e.g. a chocolate covered candy bar).

[29] Controller 232 (e.g. a microprocessor, a FPGA, a dedicated circuit, etc.) controls an electrical power supply (internal the controller or external (not shown)) to generate and apply the same voltage (e.g. of a predetermined magnitude) or different voltages

10 to the electrode pairs at locations 252 and 254 (via wires 224, 226, 228 and 230). The application of the voltages to the electrodes produces an electric field at a specified polarity along the flow direction (i.e. the delivery path 250) of the liquid chocolate, which changes the viscosity of the liquid chocolate. The magnitude of the voltages

15 applied to the electrodes along with the spacing between the electrodes determines the strength of the electric field.

[30] It is noted that the electric field may be a direct current (DC) or an alternating current (AC) electric field that is applied to the liquid chocolate. It is also noted that the metallic meshes or metallic rings may be of essentially any configuration that

20 provides an electric field along the flow direction of the liquid chocolate while allowing the liquid chocolate to pass along a flow path between the electrodes.

[31] It is noted that the applied electric field is selected to be in a strength range that is conducive to reducing the viscosity of the liquid chocolate. For example, if the electric field strength is too small, reduction in viscosity may be insignificant or may not

25 occur at all. If the electric field strength is too large, the viscosity may actually be increased.

[32] It is noted that the duration of the electric field is also chosen to be in a range that is conducive to reducing the viscosity of the liquid chocolate. In one example, after the applied electric field strength is selected, an appropriate duration of the field

30 application to the liquid chocolate may then be selected. This time duration may be related to the strength of electric field. For example, if the field is first selected to be strong, the duration may then be selected to be short. In another example, the electric field duration may be selected first, and then an appropriate electric field strength may be selected based on the duration. In general, by selecting an appropriate combination

35 of electric field strength and electric field duration, an optimal viscosity reduction for liquid chocolate may be attained.

[33] In one example, controller 232 may be programmed or controlled by an operator to ensure that a predetermined viscosity of the liquid chocolate flowing through pipe 206 is obtained. For example, controller 232 may be programmed to deliver liquid chocolate at a desired viscosity to applicator 222 to ensure that candy 246 on assembly line 242 are coated properly to produce desired chocolate products 244. These parameters along with other parameters such as temperature may be utilized by the controller 232 to determine an electric field strength and a duration to obtain a predetermined viscosity of the liquid chocolate that is beneficial for producing chocolate products such as a candy bar.

[34] In some products, a thicker chocolate may be desired while in other products, a thinner chocolate may be preferred. Thus, the viscosity of the liquid chocolate may be controlled depending on requirements of the chocolate products.

[35] Sensors (not shown) such as flow rate and/or temperature sensors may be implemented in the pipe to determine the viscosity of the liquid chocolate at one or more locations during the manufacturing process. In another example, the electrical power being consumed by the pump may also be used as an indicator of flow rate and/or viscosity of the chocolate (i.e. high power consumption may indicate high viscosity). This data may then be utilized by the controller 232 to further control the electric field applied to electrodes 208 and 210. For example the liquid chocolate may be maintained below a predetermined viscosity level to ensure proper functioning of the manufacturing equipment.

[36] It is shown in Fig. 2D that the controller may communicate (i.e. receive and/or transmit information) to control various pieces of equipment in the manufacturing process using one or more control lines. These (wired or wireless) control lines may include, but are not limited to, chocolate applicator line 234, conveyor belt line 236, operator interface line 237, pump line 238, sensor line 240 and/or valve line 241.

[37] In one example, the controller may control the production equipment by controlling the electric field applied to the liquid chocolate, pumps pumping the liquid chocolate through the pipe, applicators applying the liquid chocolate to the candy products, conveyor belts moving candy for application of liquid chocolate, heating devices heating the liquid chocolate, sensors for detecting various characteristics of the liquid chocolate (e.g. temperature, flow rate, viscosity, etc.), valves for allowing the liquid chocolate to flow through pipes and applicators, valves for mixing ingredients (e.g. melted fat) into the liquid chocolate and a user interfaces for interfacing (i.e. inputting and outputting information) to an operator.

[38] Figure 3A is a test bench setup that was utilized to test the viscosity of liquid chocolate in the presence of an electric field. As shown in Figure 3A, a heating surface

306 maintains the chocolate in a liquid form. The liquid chocolate 308 is then forced through metallic meshes 310 and 312 by a weight 302 and piston 304. As the liquid chocolate 308 is forced between electrodes 310 and 312, it is exposed to an electric field if a voltage is applied to the electrodes and its viscosity is reduced (i.e. its flow rate is increased if an electric field of a desired strength and duration is applied). The liquid chocolate with low viscosity is then collected in a container 314. The flow rate is then measured by a computer 318 connected to a balance 316.

[39] In one experiment, the liquid chocolate is maintained around 40°C utilizing heating surface 306. Under gravity, the liquid chocolate flowed through the metallic meshes 310 and 312 which applied a predetermined electric field in the flow direction of the chocolate. The balance 316 measured the liquid chocolate's mass as a function of time. This allowed the flow rate through pipe 320 to be determined.

[40] Figure 4A shows a graph of the flow rate of the liquid chocolate (402, 404, 406, 408 and 410) versus time for the test bench in Figure 3A. For the data in Figure 4A, there was no additional weight applied. The liquid chocolate first flowed down through the pipe without any electric field being applied. The flow rate was approximately 0.0106 g/s (see 402) indicating that the viscosity of the liquid chocolate is about 41.3 Pa.s. After an electric field of 575 V/cm was applied, the flow rate was increased to 0.01798 g/s (see 404) which reduced the viscosity to 24.46 Pas. (i.e. a 41% decrease in viscosity after being exposed to the electric field). In this experiment, the liquid chocolate took approximately 1 minute to flow by the two electrodes and into container 314.

[41] After 10 minutes, the electric field was turned off, and the flow rate began to decrease indicating that the reduced viscosity gradually returned to its original value (i.e. see data 406, 408 and 410 where the flow rate gradually decreases over time after the electric field has been turned off). In other experiments, the electric field was reapplied to the liquid chocolate and the viscosity reduction was repeated.

[42] Figure 3B is another test bench similar to the test bench in Figure 3A. However, the test bench in Figure 3B uses pressurized gas (not a weight) to force the liquid chocolate through pipe 320. Also, the test bench in Figure 3B is located inside an incubator 328 to keep the chocolate at a desired temperature. Heating surface 306 is therefore not needed in this test bench.

[43] In general, pressurized gas (e.g., nitrogen) under control of computer 318 is applied to liquid chocolate 308 through pipe 322. In response to the applied pressure, liquid chocolate 308 is forced through electrified meshes 310/312, through tube 320 and into container 314 where its weight is measured by balance 316. The test bench in

Figure 3B also may include a temperature sensor 326 that allows the computer to monitor the temperature of the liquid chocolate during the testing process.

[44] Figure 4B shows the relationship between the application time of the electric field and the optimal electric field strength for the test bench in Figure 3B. In general, as the application time increases, the strength of the electric field decreases (i.e., the longer it takes for the chocolate to flow through the electric field, the lower the electric field strength needs to be). This inverse relationship is shown in rows 412, 414, 416, 418, 420 and 422 of the table in Figure 4B.

[45] Figure 4C shows a graph of the viscosity of the liquid chocolate (424 and 426) versus time for the test bench in Figure 3B. In one example, (corresponding to row 414 in Figure 4B) a chocolate sample at 40°C took 9.37 seconds to flow through an electric field with a strength of 1838 V/cm. In this example, the viscosity was reduced from 43.23 Pa.s (see 424) to 29.53 Pa.s (see 426). This particular electric field application produced a 31.7% reduction in viscosity.

[46] For tempered chocolate, it was found that the electric field needed to be slightly higher. In general, to temper chocolate, solid chocolate is shaved. To produce fine shavings, a mesh is used to filter the particles. Solid chocolate with diameter less than a set size (e.g., 150 micro-meters) are used as seeds. About 1kg chocolate was melted at 40°C and cooled down to 30°C. After 10g fine solid chocolate was mixed, the experiment using the test bench began. It is noted that the viscosity of the tempered chocolate increases very fast. It solidifies in about 30 minutes. Within this period, however, an electric field may be applied to reduce its viscosity.

[47] Figures 4D and 4E show graphs of flow rate (428, 430, 432, 434, 436, 438 and 440) and viscosity (442, 444, 446, 448, 450, 452 and 454) versus time respectively for the tempered chocolate. As shown in Figure 4D, nine minutes after the mixing, the flow rate was 0.477545 g/s (see 428) under 1.56 Psi of pressure. When the electric field 1.2kV/cm was turned on, the flow rate increased to 0.584745 g/s (see 430) (an increase of 22.45%). After 100 seconds of electric field application, the electric field was turned off and the corresponding flow rate was 0.465407 g/s (see 432). The flow rate was measured every 30 seconds thereafter. In about 180 seconds, the flow rate decreased to 0.33801 g/s (see 440) (reduced by 27.3%). This indicated that the tempered chocolate was solidifying.

[48] From the flow rate, it was found that the viscosity (see Fig. 4E) was about 121.82 Pa.s (see 442) at nine minutes after the mixing. When an electric field of 1.2 kV/cm was applied, the viscosity was down to 99.487 Pa.s (see 444). After the electric field was turned off, the viscosity was 125.0 Pa.s (see 446). In another three minutes, the viscosity was increased to 172.1 Pa.s (see 454).

[49] It is noted that the inventors have discovered that a suitable range for the electric field is from 100 V/cm to 6000V/cm, and works particularly well in the range of 500 V/cm to 800 V/cm for some types of chocolate (e.g. Milk Chocolate available from Hershey of Hershey Pennsylvania). If the electric field applied is too weak, there may
5 be no noticeable viscosity reduction. On the other hand, if the applied electric field is too strong, the viscosity may actually increase. Because the liquid chocolate has a strong electrorheological effect (ER) the solid structure aggregates may become too large if exposed to an electrical field that is too strong, which would lead to increased viscosity (i.e. if the aggregates increase from micro-meter size to a larger macro-scopic
10 size).

[50] As described above, the duration of the electric field may be chosen based on the selected strength of the electric field (i.e. if the field is stronger, then the duration may be shortened) or visa versa. It is also noted that the duration of the electric field applied to liquid chocolate is equal to the time for the liquid chocolate to pass through
15 the electric field. This duration can be changed if needed by adjusting the flow rate of the liquid chocolate (e.g. increasing/decreasing pump power), and/or by increasing/decreasing the gap between the two electrodes. By selecting a combination of an electric field strength and a duration of the field, viscosity reduction can be optimized for the flow of liquid chocolate through a pipe. It is furthermore noted that
20 the electric current flowing between the meshes in the test benches was found to be very small (e.g., a couple of micro amperes). This indicates that the system is energy efficient while reducing the viscosity of the chocolate.

[51] Although the invention is illustrated and described herein with reference to specific embodiments, the invention is not intended to be limited to the details shown.
25 Rather various modifications may be made in the details within the scope and range of equivalence of the claims and without departing from the invention.

CLAIMS

1. A method for producing a chocolate product, the method comprising:
delivering liquid chocolate having a viscosity through a pipe along a delivery
path to a production station for producing the chocolate product, the liquid chocolate
5 including solid particles suspended within the liquid chocolate; and
changing the viscosity of the liquid chocolate by applying an electric field to the
liquid chocolate in a direction along the delivery path of a strength and duration
determined to aggregate the suspended solid particles into streamlined shapes
extending along the direction of the delivery path.
- 10 2. The method of claim 1, wherein changing the viscosity comprises:
applying the electric field in a strength range of 300V/cm to 1000V/cm.
3. The method of claim 1,
wherein the liquid chocolate comprises melted fat and the solid particles
suspended in the melted fat, and
15 wherein the suspended solid particles include at least one of sugar particles,
cocoa particles or milk particles.
4. The method of claim 1, further comprising:
determining the strength and duration for applying the electric field to the liquid
chocolate based on a predetermined consistency of the chocolate product.
- 20 5. The method of claim 1, further comprising:
determining the strength and duration for applying the electric field to the liquid
chocolate based on a predetermined fat content of the chocolate product.
6. The method of claim 1, further comprising:
determining the strength and duration for applying the electric field to the liquid
25 chocolate based on a type of chocolate used in the production of the chocolate product.
7. The method of claim 1,
controlling the strength and duration for applying the electric field based on the
determined flow rate of the liquid chocolate along the delivery path.
8. The method of claim 1,
30 controlling the strength and duration for applying the electric field based on the
determined viscosity of the liquid chocolate along the delivery path.
9. The method of claim 1,
tempering the liquid chocolate prior to delivering the liquid chocolate through
the pipe.
- 35 10. A system for producing a chocolate product, the system comprising:

a chocolate delivery pipe for flowing liquid chocolate having a viscosity along a delivery path to a production station for producing the chocolate product, the liquid chocolate including solid particles suspended in the liquid chocolate; and

at least two electrodes integrated into the chocolate delivery pipe for changing
5 the viscosity of the liquid chocolate by applying an electric field to the liquid chocolate in a direction along the delivery path of a strength and duration determined to aggregate the solid particles into streamlined shapes extending along the direction of the delivery path.

11. The system of claim 10,
10 wherein the at least two electrodes are metallic meshes coupled to a pair of respective output terminals of an electric power supply that produce the electric field.

12. The system of claim 10,
wherein the at least two electrodes are metallic rings coupled to a pair of respective output terminals of an electric power supply that produce the electric field.

13. The system of claim 10, further comprising
15 a controller coupled to the at least two electrodes to control the strength and duration of the electric field applied to the liquid chocolate to reduce the viscosity to a predetermined level.

14. The system of claim 10, further comprising
20 a controller, and
wherein the controller controls a flow rate of the liquid chocolate to adjust the duration during which the electric field is applied to the liquid chocolate.

15. The system of claim 10, wherein
the electrodes are spaced to produce a gap between the electrodes, and
25 the gap is adjusted to control the duration during which the electric field is applied to the liquid chocolate.

16. The system of claim 10, further comprising
a source of melted fat; and
a controller controlling an amount of melted fat included in the liquid chocolate
30 based on the electric field.

17. The system of claim 10, further comprising
a sensor located in the chocolate delivery pipe for measuring a flow rate or viscosity of the liquid chocolate.

18. The system of claim 17, further comprising
35 a pump for pumping the liquid chocolate through the chocolate delivery pipe, a speed of the pump being controlled based on a signal received from the sensor located in the chocolate delivery pipe.

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19. A system for producing a chocolate covered candy product, the method comprising:

a chocolate delivery pipe and a pump for flowing liquid chocolate having a viscosity along a delivery path to an applicator, the liquid chocolate including solid particles suspended in the liquid chocolate, the applicator applying the liquid chocolate to a candy product to produce the chocolate covered candy product;

at least two electrodes integrated into the chocolate delivery pipe for changing the viscosity of the liquid chocolate by applying an electric field to the liquid chocolate in a direction along the delivery path to the applicator of a strength and duration to aggregate the suspended solid particles into streamlined shapes extending along the direction of the delivery path; and

a controller for controlling the strength of the electric field, the duration of the electric field and a pumping speed of the pump to supply liquid chocolate at a predetermined viscosity to the applicator.

20. The system of claim 19, further comprising

at least two other electrodes integrated into the chocolate delivery pipe for changing the viscosity of the liquid chocolate by applying another electric field to the liquid chocolate in a direction along the delivery path to the applicator.

21. The system of claim 19, further comprising

sensors integrated into the chocolate delivery pipe for sensing a flow rate or a viscosity of the liquid chocolate.

22. The system of claim 19, wherein

the controller determines a flow rate or a viscosity of the liquid chocolate based on electric power consumption of the pump.

23. The system of claim 19, wherein

the liquid chocolate is pumped from a liquid chocolate tank and the controller controls mixing of the liquid chocolate in the tank based on the predetermined viscosity.

24. The system of claim 19, wherein

the controller includes an operator interface having an input and a display for an operator of the system to manually control the flow rate or viscosity of the liquid chocolate.

25. The system of claim 19, wherein

the at least two electrodes are metallic electrodes coated with non-conductive food grade plastic.

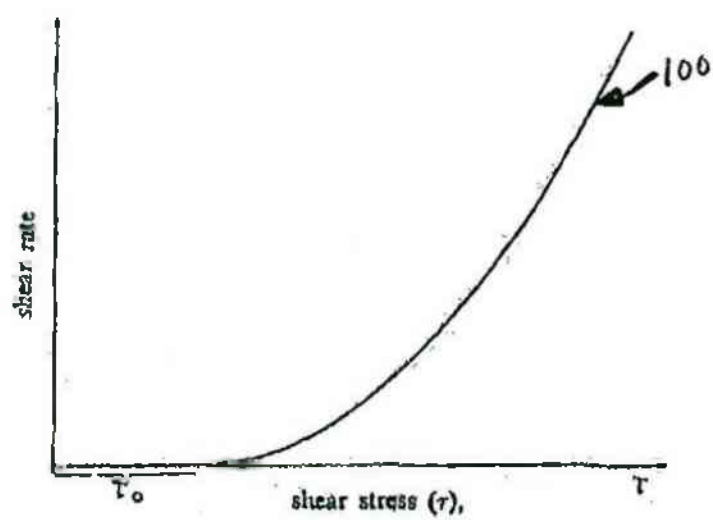


Fig. 1

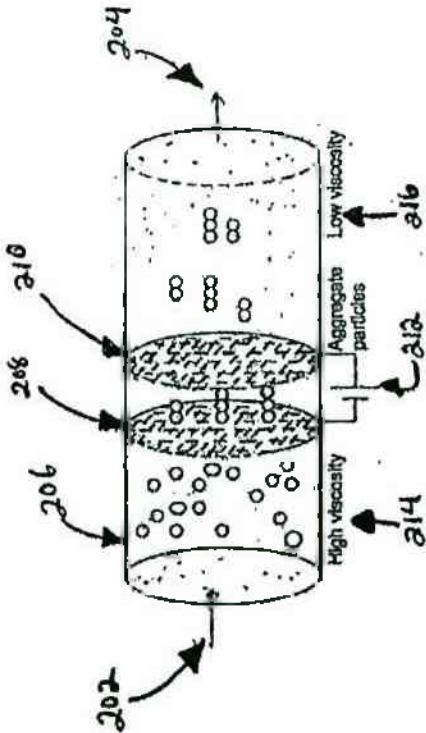


Fig 2A

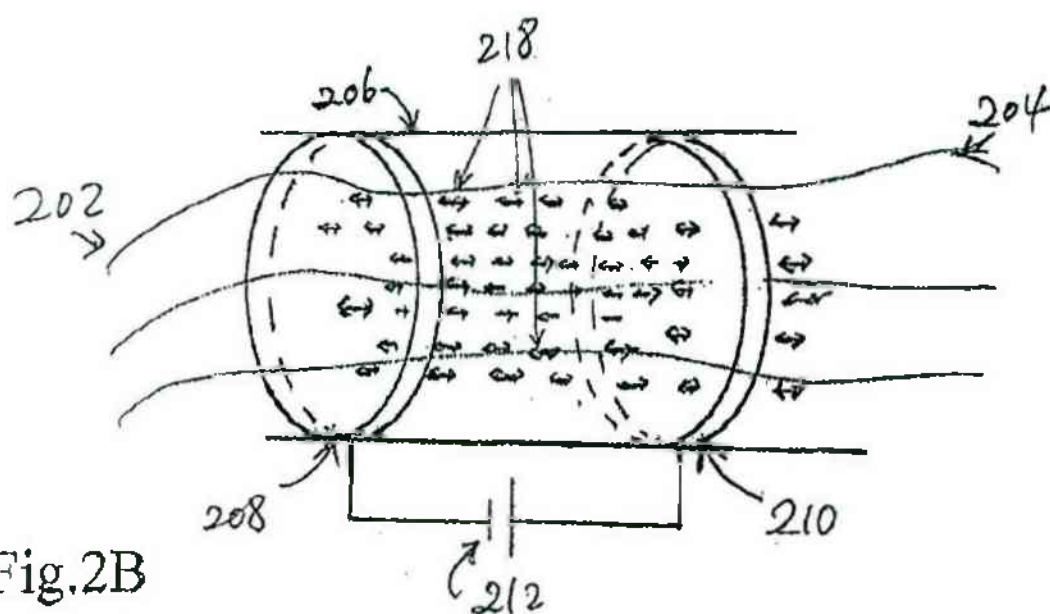


Fig.2B

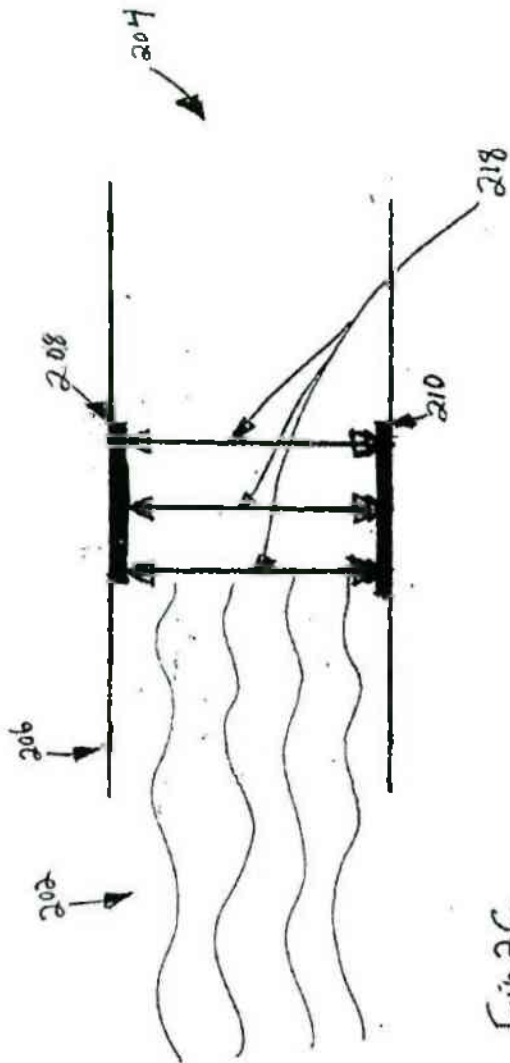


Fig 2C

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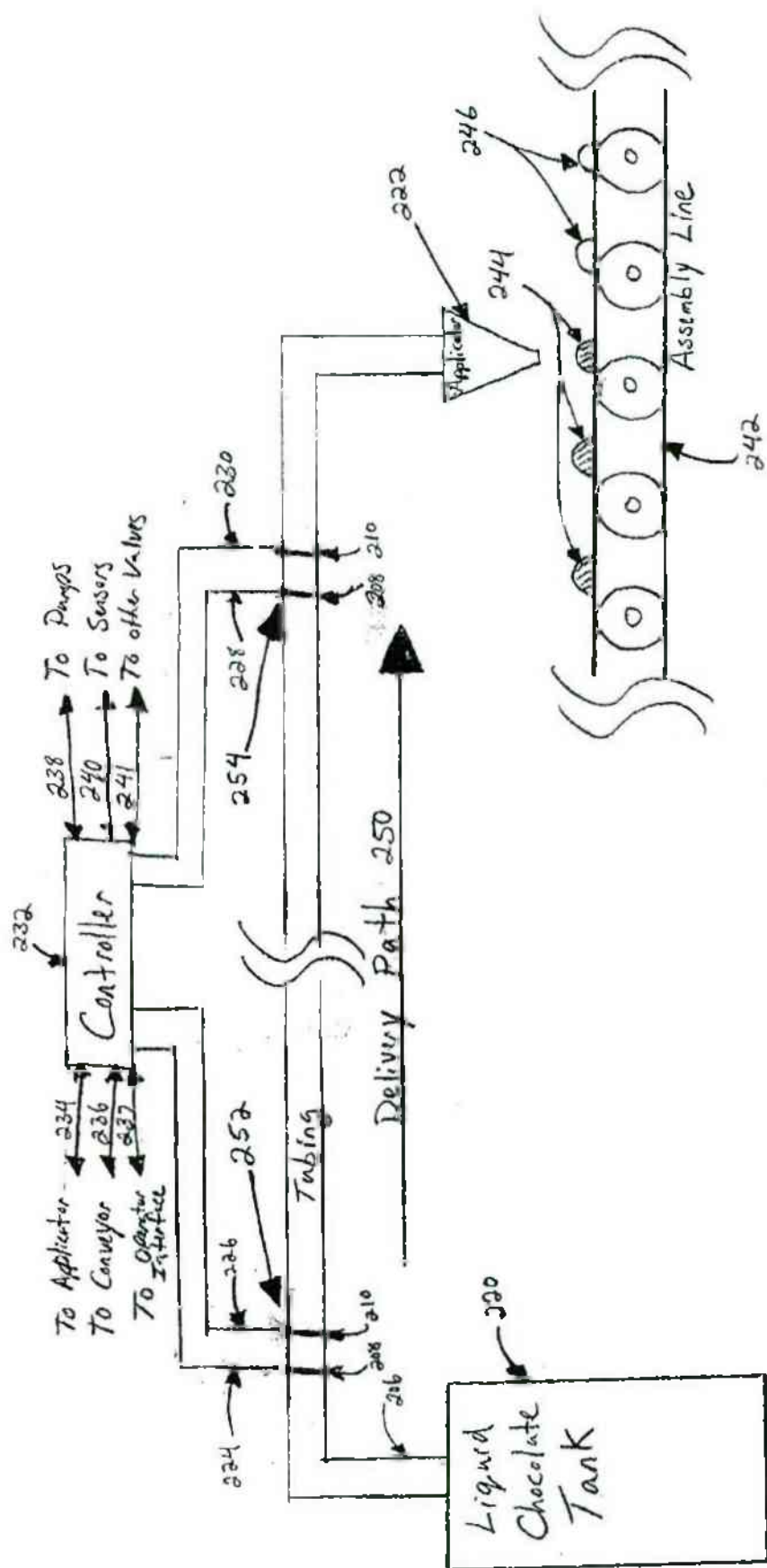


Fig. 2D

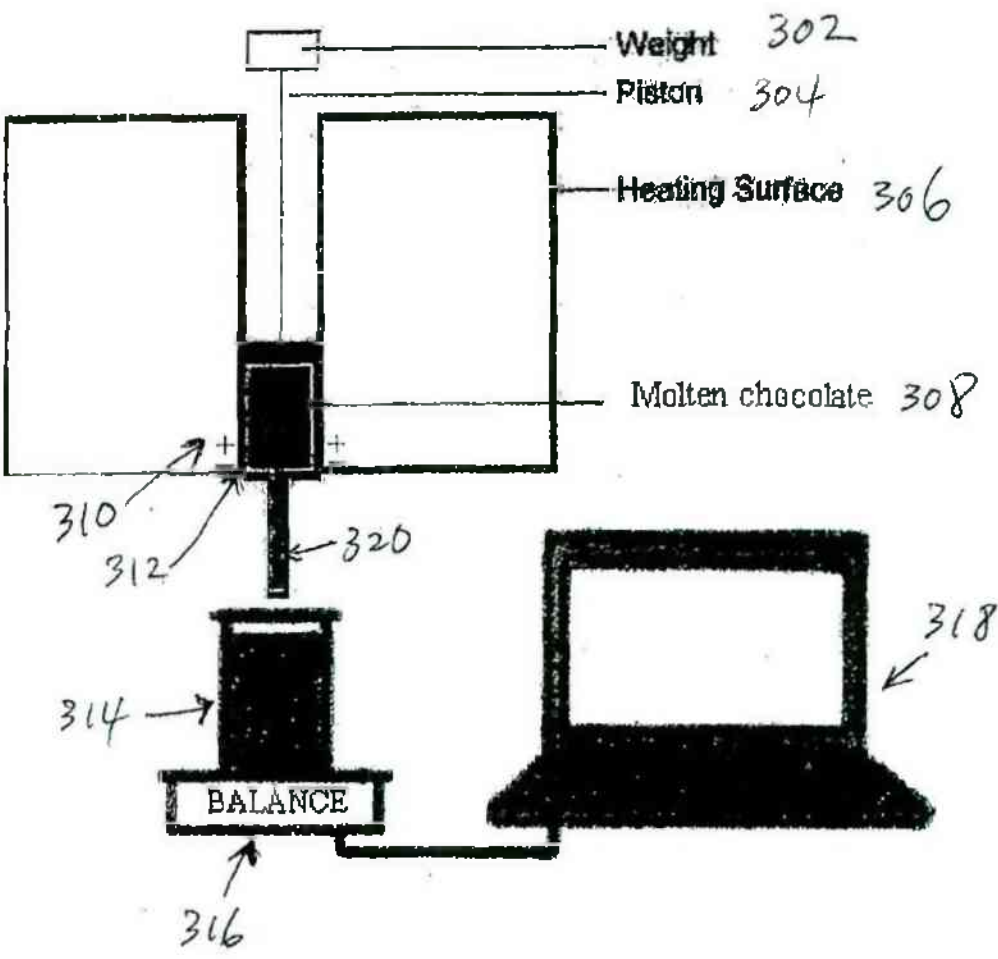
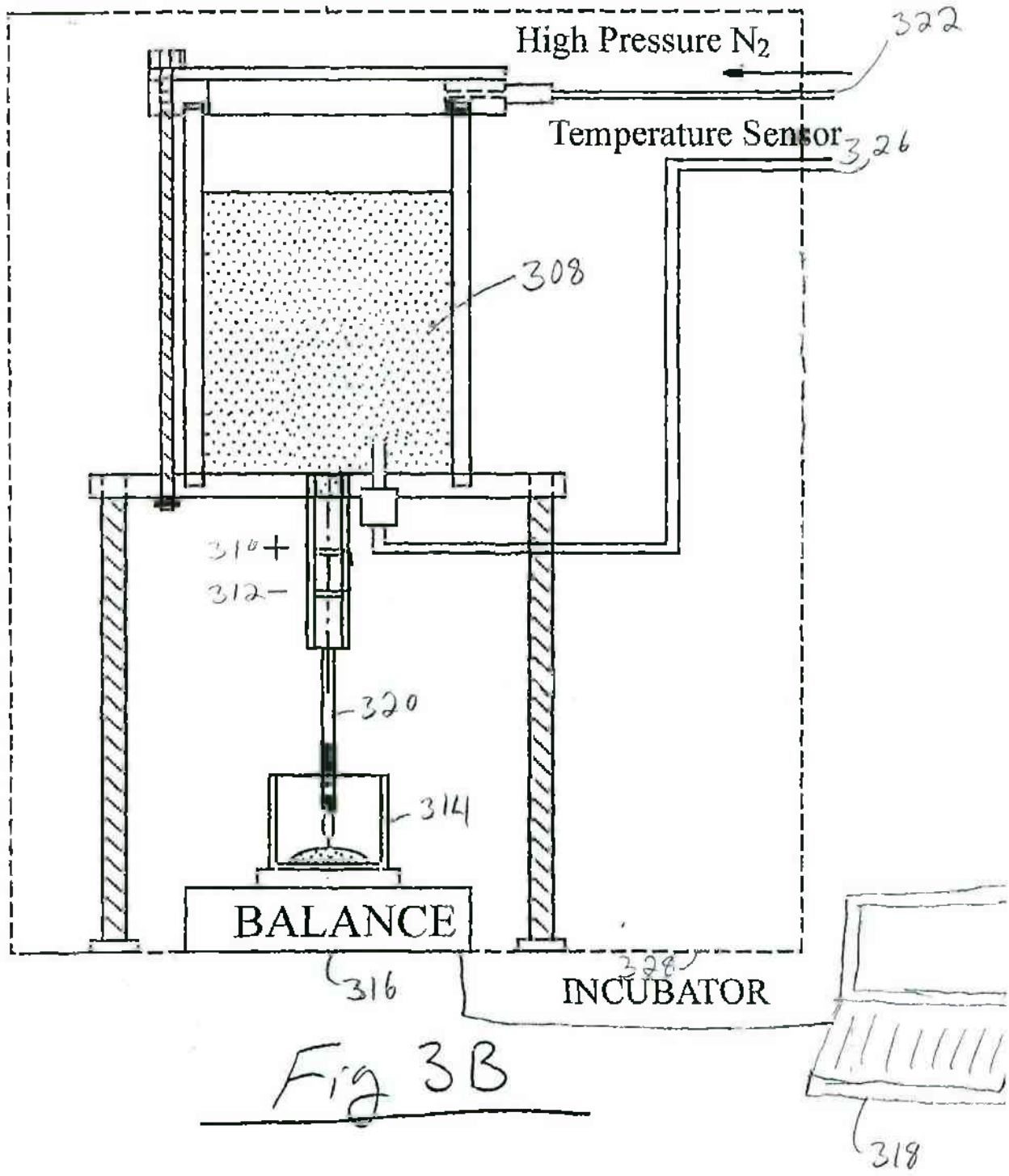
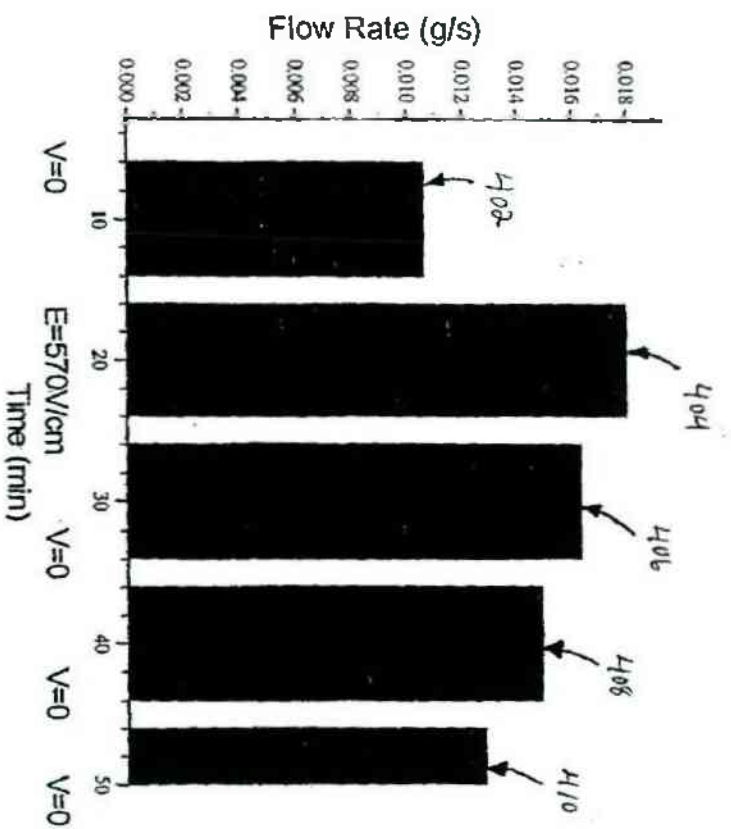


Fig. 3A

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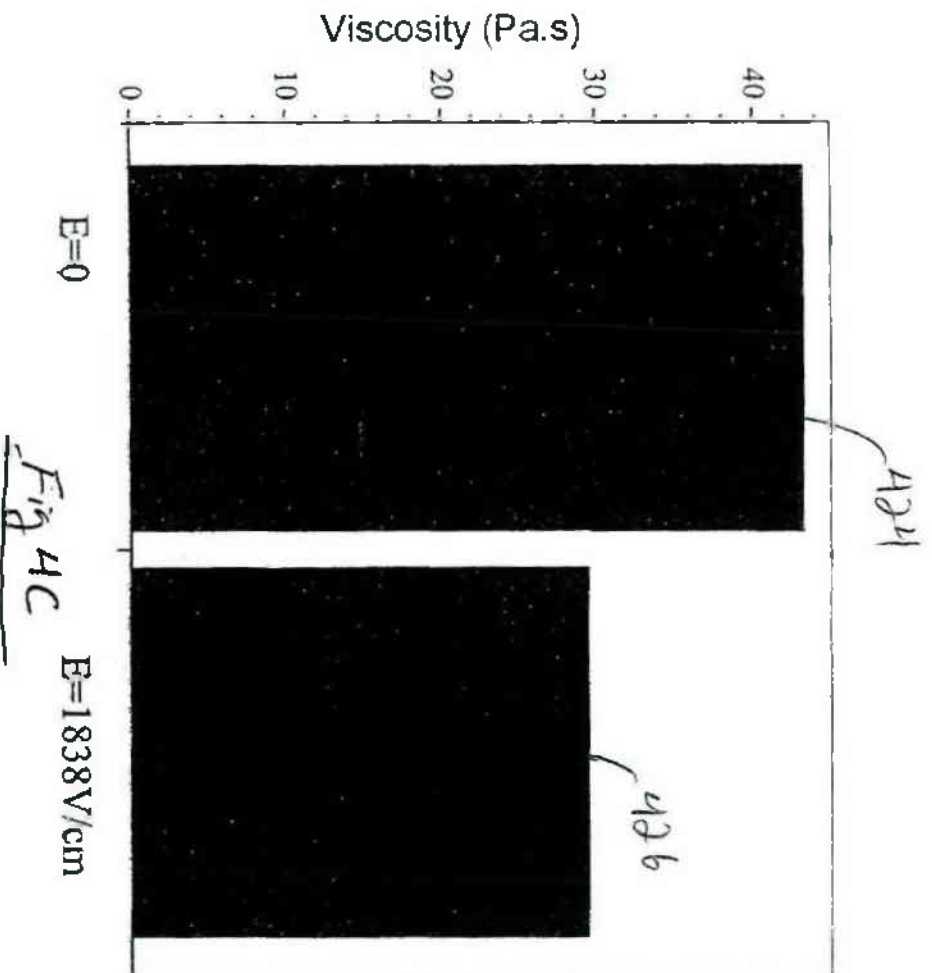
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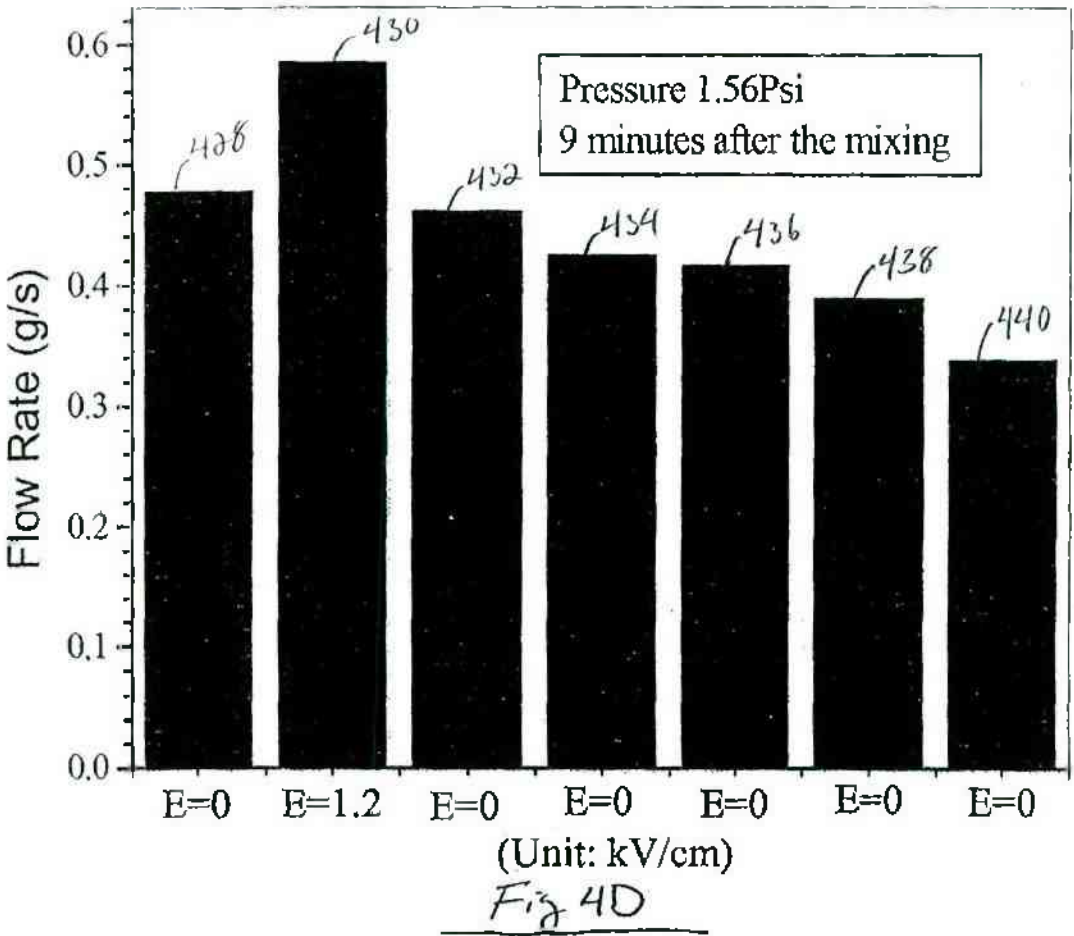
Fig 4A

	Time for the chocolate flow to pass the electric field (s)	Optimal Electric Field (V/cm)
412	5.0	2517
414	9.37	1838
416	13.7	1520
418	19.0	1291
420	24.2	1144
422	39.3	898

FIG 4B

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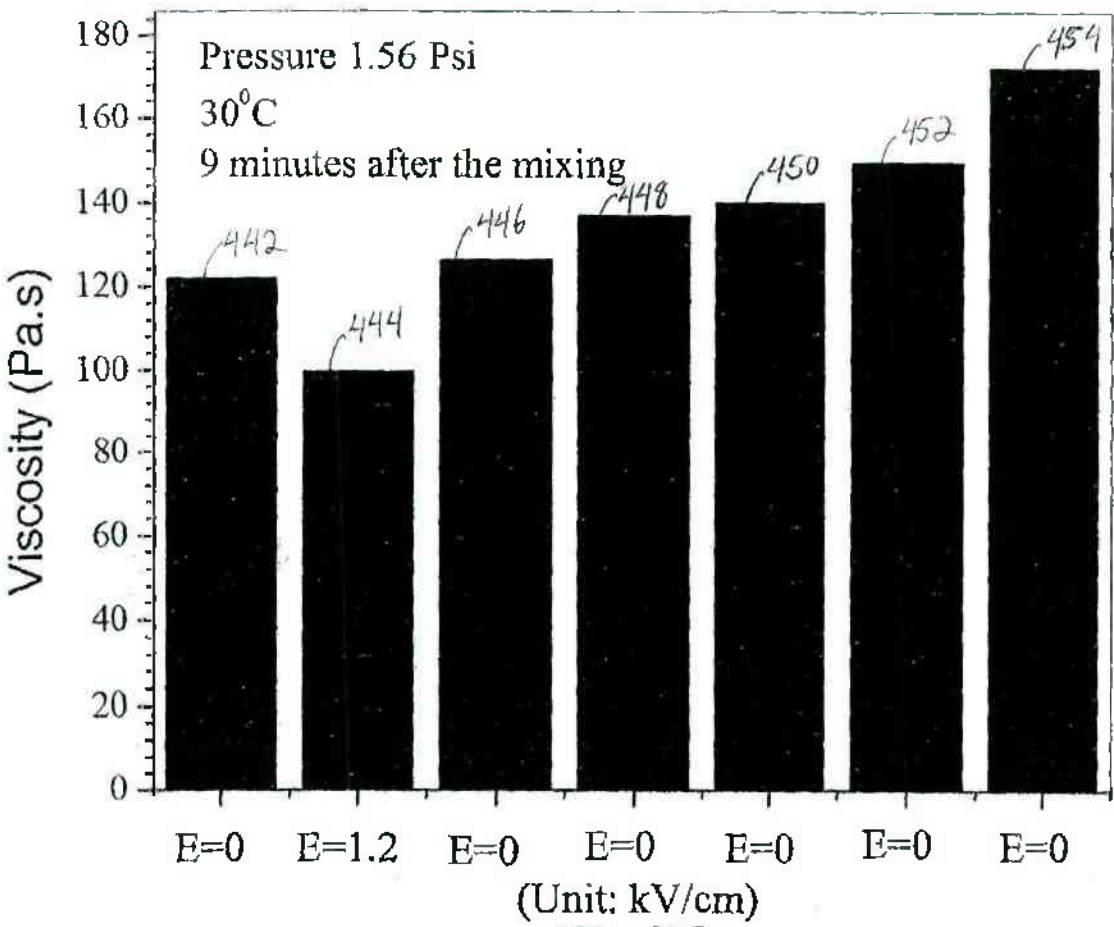


Fig 4E

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/023988

A. CLASSIFICATION OF SUBJECT MATTER

A23G 1/04(2006.01); A23G 1/50(2006.01);

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A23G 1/04; A23G 1/50

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: chocolate electric field electrode candy viscosity

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/012032 A1 (CAVITUS PTY LTD et al.) 04 February 2010 See page 7, lines 30-32, page 12, lines 13-15, page 13, lines 5-6, page 18, lines 30-31, page 21, lines 10-11; claims 1, 18; figures 2, 9.	1-25
A	US 04208440 A (SCHWIDT; EDWARD D.) 17 June 1980 See column 2, lines 30-33; claim 1.	1-25
A	US 2001-051377 A1 (ANDREW STEVE WHITEHOUSE et al.) 22 January 2004 See claims 1, 3, 6, 12.	1-25
A	ES 2011-0217432 A1 (KRNIC PETER et al.) 08 September 2011 See abstract; claims 6-8, 16.	1-25
A	ES 1733258 A (CAPODIECI; ROBERTO A.) 26 July 1994 See abstract; claims 19, 20.	1-25
A	ES 05070045 A (CULLY; KEVIN JOHN et al.) 14 October 1997 See abstract; column 3, lines 2-4; claim 1.	1-25

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "I" document which may throw doubts on priority claims) or which is cited to establish the publication date of citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "L" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family

Date of the actual completion of the international search 17 June 2013 (17.06.2013)	Date of mailing of the international search report 17 June 2013 (17.06.2013)
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Name and mailing address of the ISA/KR  Korean Intellectual Property Office 189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer YANG, In Su Telephone No. 82-42-481-8131 
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INTERNATIONAL SEARCH REPORT
 Information on patent family members

International application No.
PCT/US2013/023988

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

NIT : 800.176.089-2

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Industria y Comercio
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CONSIGNACION	BANCO DE BOGOTA	062754387	686775213	22/08/2014	1.106.000.00

*** Conceptos Pagados ***

CANT.	RENTISTICO	CONCEPTO	Vr.UNDITARIO	Vr.CONCEPTO
15 50005-01-01	SOLICITUDES	1607 REIVINDICACION PATENTE UNITARIA ADICIONAL A LAS 10 INIC	31.000.00	465.000.00
				\$465.000.00

SON: **CUATROCIENTOS SESENTA Y CINCO MIL PESOS MONEDA CORRIENTE***

Responsable: _____

Recibo de Caja Aplicado al Expediente No. _____

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No. 14-184850- -00000-0000

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Act: 411 PRESENTACION

Dep. 2020 DIR NUEVASCR
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Folios: 86

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Web: www.sic.gov.co e-mail: info@sic.gov.co Conmutador: (571) 5870000 Fax: (571) 5870284 Línea: 018000-910165 Call Center: (571) 6513240

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RECIBIDO DE : TRIANA URIBE & MICHELSEN LTDA

NI 830.001.432

*** Soporte del Pago ***

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CONSIGNACION	BANCO DE BOGOTA	062754387	686775213	22/08/2014	1.106.000.00

*** Conceptos Pagados ***

CANT	RENTISTICO	CONCEPTO	Vr. UNIDITARIO	Vr. CONCEPTO
1	50005-01-01 SOLICITUDES	1 TRAMITES DE SOL. DE PATENTE DE INVENCIÓN	515.000.00	515.000.00
				\$515.000.00

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SON: **QUINIENTOSQUINCE MIL PESOS MONEDA CORRIENTE**

Responsable: _____

Recibo de Caja Aplicado al Expediente No. _____

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Act 411 PRESENTACION Folios 86

PATENTE DE INVENCION ☐

MCI

1/00

☐	Indicación que se solicita una patente.
☐	Datos de identificación del solicitante o de la persona que presenta la solicitud
☐	Descripción de la invención
☐	Dibujos de ser estos pertinentes
☐	Comprobante de pago de las tasas establecidas (De ser el caso formato de descuento)
☐	Completa ☐ Incompleta ☐

PATENTE DE INVENCION PCT ☐ MODELO DE UTILIDAD PCT ☐ Art.33 Decisión 486/00, Circular Única

☐	Indicación que se solicita una PCT
☐	Copia de la solicitud en español, tal como fue presentada inicialmente (capítulo descriptivo, reivindicatorio, resumen)
☐	Dibujos de ser estos pertinentes
☐	Comprobante de pago de las tasas establecidas (de ser el caso formato de descuento)
☐	Completa ☐ Incompleta ☐

DISEÑO INDUSTRIAL ☐

(Art. 119 Decisión 486/00)

☐	Indicación que se solicita Diseño Industrial
☐	Datos de identificación del solicitante o de la persona que presenta la solicitud
☐	Representación gráfica y fotográfica del Diseño industrial o muestra del material que incorpora el diseño
☐	Comprobante de pago de las tasas establecidas
☐	Completa ☐ Incompleta ☐

ESQUEMA DE TRAZADO ☐

(Art. 92 Decisión 486/00)

☐	Indicación que se solicita un esquema de trazado
☐	Datos de identificación del solicitante o de la persona que presenta la solicitud
☐	Representación gráfica de un esquema de trazado
☐	Comprobante de pago de las tasas establecidas
☐	Completa ☐ Incompleta ☐